California Water Plan - Update 2004

June 7, 2004

ADVISORY COMMITTEE REVIEW DRAFT

Volume 2: Resource Management Strategies

Statewide Water Planning Branch
Department of Water Resources

June 7, 2004

WORKING DRAFT of REPORT

The California Department of Water Resources has posted for review and comment an ADVISORY COMMITTEE REVIEW DRAFT of Volumes 1, 2, 3 and 4 of the California Water Plan – Update 2004. These files are also available electronically at web site address:

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The deadline for receiving comments on this AC Review Draft is:

For Volume 1 - June 24, 2004
For Volumes 2, 3 & 4 - July 2, 2004

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Introduction – Resource Management Strategies

A key objective of the California Water Plan is to present a diverse set of resource management strategies to meet the water related resource management needs of each region and the state as a whole. Chapter 4 of Volume 1 describes the importance of regional planning and presents general considerations for preparing sustainable integrated resource plans suitable for each region's unique character. This volume describes 25 resource management strategies (listed alphabetically in the adjacent box and in narratives following the introduction) that can be combined in various ways to meet the water management objectives and values of different regions and to achieve multiple resource benefits.

What are Resource Management Strategies?

As used in this report, a resource management strategy is a project, program or policy that helps California's local agencies and governments manage their water and related resources. For example, urban water use efficiency to reduce urban water use is a strategy. A pricing policy or incentive for customers to reduce water use is also a strategy. New water storage to improve water supply, reliability or quality is a strategy.

Some may like to think of these strategies as individual tools in a tool kit. Just as the mix of tools in a tool kit will vary depending on the job to be performed, the combination of strategies will vary from region to region depending on the individual situations surrounding their water supply and use, climate, projected growth, and environmental and social conditions. Some strategies may have little value in some regions. For example, due to geologic conditions, the opportunity for groundwater use in the mountain counties is not nearly as significant as in the Sacramento Valley.

Resource Management Strategies

Agricultural lands stewardship
Agricultural water use efficiency
Conjunctive management
Conveyance
Desalination
Drinking water treatment and distribution
Economic incentives (loans, grants and water pricing)
Ecosystem restoration
Floodplain management
Groundwater remediation / Aquifer Remediation
Matching water quality to use
Other resource management strategies
Pollution prevention
Precipitation enhancement
Recharge area protection
Recycled municipal water
Surface storage - CALFED
Surface storage - regional/local
System reoperation
Urban land use management
Urban runoff management
Urban water use efficiency
Water-dependent recreation
Watershed management
Water transfers

Planning a Diversified Portfolio

As conditions continue to change in California, many local agencies and governments continue to diversify their water management portfolios to meet human and environmental needs. Growing population, changing regulations, and evolving public attitudes are a few conditions that have influenced recent portfolio decisions for water and other resources. This diversification has become even more essential with the growing understanding of the concurrent water demands of farms, cities and the environment and the need to achieve multiple benefits.

Resource managers need to examine all of these strategies to identify the best mix for their region. The more a region can diversify its portfolio, the more robust and resilient it will be in facing future unknowns.

The strategies described in this volume are the building blocks that local agencies and governments should consider in developing their future regional integrated resource plans. The basic intent is to prepare good plans that are diversified, satisfy regional and state needs, meet multiple objectives, are inclusive of public input, address environmental justice concerns, display and mitigate impacts, protect public trust assets, and are affordable. Recommendations for future planning and implementation can be found in Chapter 4 of Volume 1.

While the strategies are based on the best available information, DWR has not conducted detailed studies to verify this information on a statewide basis because the performance of individual strategies will depend on how they are combined and used in each region. DWR, with the assistance of the Advisory Committee, is developing a work plan for more comprehensive and robust data and analytical tools for use in the Water Plan Update in 2008. Additional analyses under Phases 2 and 3 of the update process (described in Chapter 1 of Volume 1) will provide policy makers and resource managers more quantitative information on the performance of various strategies, interactions between strategies, tradeoffs, and potential groupings or packages of strategies. Because the future is uncertain and stakeholders have a range of perspectives on how strategies could be integrated, DWR will consider several different future scenarios in the future Bulletin 160-08 that can be used by planners to test the performance of alternative strategy mixes.

Organization of Resource Management Strategy Narratives

Following this introduction are articles on 25 resource management strategies. While the articles were written by different experts, the narratives for each strategy are arranged in a similar format:

- Each article begins with a short definition and background material on the strategy.
- A section on the current use of the strategy in California provides an overview of what is happening under today's conditions.
- A section on benefits includes a discussion on how much water supply, demand reduction, ecosystem restoration, or other benefits could be achieved on a statewide basis by 2030. Since the potential application of these strategies can vary widely among the various regions, the strategy descriptions are from a broader, statewide perspective. More detailed information on some of the strategies is also presented in the Reference Guide (Volume 4).
- The narratives include estimates on implementation costs when information is available. In most cases, costs are highly dependent on site specific implementation and can only be portrayed in broad ranges.
- It is also important to recognize that there are issues and challenges associated with implementing each strategy. For instance, with water transfers there are concerns about third-party impacts. With ocean water desalination there are issues with water intakes and brine disposal. For new off stream surface water storage there are questions about impacts of diversions on the rivers that would provide the water. With agricultural water use efficiency, there are potential impacts on downstream environmental resources dependent on tail water runoff.
- Each strategy narrative contains recommendations on how the strategy could be implemented over the next 25-30 years to minimize its impacts, as well as how to promote additional implementation. Many of the recommendations are for the state to enact technical support activities that will help the regional groups make better decisions for the use of the strategies. The narratives do not include

specific recommendations for funding implementation of individual strategies since local and regional efforts will need to complete additional analysis before making implementation decisions. However, each strategy will require funding if implemented.

While the resource management strategies are presented individually (and alphabetically) to simplify the presentation, the potential for synergistic effects and trade-offs should also be examined. For instance, water from a recycling project could contribute to ecosystem restoration and groundwater recharge; while upstream water use efficiency may reduce the opportunity for downstream recycling and reuse.

In addition, the strategy narratives and their related recommendations are designed to recognize the many interactions between water and other resources. However, DWR does not have authority over some of these resources, and other state and local agencies and governments will continue to set policy over the resources within their jurisdictions. As appropriate, these policies and programs are articulated in the various resource management strategy narratives.

Strategy Investment Options Table

The Strategy Investment Options Table (see following table) provides a one page overview of the 25 resource management strategy articles. DWR and stakeholder staff with expertise in each specific strategy developed the data and information presented in the table and the narratives. The information is not directly comparable across strategies, but should be treated as preliminary indicators of the scale and type of potential benefits and associated estimated costs. In most cases, assumptions and methodologies are unique to given strategies and neither benefits nor costs are additive among different strategies. Costs of actually implementing these strategies in specific locations could be significantly less or greater depending upon the extent of implementation that has already occurred and other local factors. Local and regional water management efforts should develop their own estimates of both costs as well as potential water supply benefits associated with any particular strategy.

Note that the benefits in the table are displayed as average annual amounts in million acre-feet, but that costs are displayed as the sum (over about 25 years) of expected costs by year 2030. Neither the estimates of benefits nor costs are suited for estimating unit water costs.

Table Layout

The actions in the table are grouped by **resource management strategies** (top section) and **essential support activities** (bottom section), like planning and research & development. The table presents the resource management strategies in subgroups according to the type of strategy. Groupings include demand reduction, operational efficiency & redistribution of water, supply augmentation, water quality and resource stewardship. While these groupings are intended to aid review of the table, the 25 resource management strategy articles on the following pages are arranged in alphabetical order so they can be more easily located. Table columns include:

- **Column 1** shows the *Resource Management Strategies* (top section) and *Essential Support Activities* (bottom section) that are available to regions to achieve various water management objectives.
- **Column 2** shows the estimated *Potential Water Supply Benefits by 2030*, with a footnote describing which benefit would be achieved and data sources. These benefits are displayed as average annual amounts in million acre-feet per year. A dot (●) is shown for strategies that would have a supply benefit that could not be quantified at this time.

- **Columns 3-10** show other *Water Management Objectives* that could be achieved by implementing a strategy. A dot (●) is shown if a strategy could have direct and significant benefits for various water management objectives. In addition to these primary benefits shown with a dot (●), most strategies also provide other benefits as indicated in the strategy narratives.
- **Column 11** shows a range of *Cumulative Costs for each Option by 2030* of implementing a strategy or performing a support activity to achieve the indicated annual benefits by 2030 (not including ongoing operation and maintenance costs). These costs are displayed as the sum of costs over about the 25-year period. Details on implementation and financing are presented in Chapter 5.

Table Footnotes

General and specific notes are listed on the pages directly following the table.

Strategy Investment Options

	Water Management Objectives										Cumulative Cost of Option by 2030	
	Provide Water Supply Benefit MAF per year		Improve Drought Preparedness	Improve Water Quality	Operational Flex & Efficient	Reduce Flood Impacts	Environmental Benefits	Energy Benefits	Recreational Opportunities	Reduce GW Overdraft	Billion $	
Resource Management Strategies												
Demand Reduction												
Agricultural Use Efficiency	0.3 – 0.6	(a)		●			●				0.13 – 2.5	(b)
Urban Use Efficiency	1.5 – 2.5	(c)		●			●				staff	(d)
Operational Efficiency & Redistribution of Water												
Conveyance			●		●						1.13	(e)
System Reoperation	0.15	(f)			●	●	●					(g)
Water Transfers		(h)	●	●	●		●				staff	(i)
Supply Augmentation												
Conjunctive Management & Groundwater Storage	0.5 – 1.5	(j)	●	●	●					●	1.5 – 4.5	(k)
Desalination – Brackish	0.1 – 0.3	(l)	●	●							0.2 – 1.6	(m)
Ocean	0.2	(n)	●	●							0.7 – 1.3	(o)
Precipitation Enhancement	0.3 – 0.4	(p)	●					●			0.2	(q)
Recycled Municipal Water	0.9 – 1.4	(r)	●	●							6.0 – 9.0	(s)
Surface Storage – CALFED	0.7 – 1.0	(t)	●	●	●	●					3.3 – 5.6	(u)
Surface Storage – Regional/Local	●		●	●	●	●						(v)
Water Quality												
Drinking Water Treatment & Distribution				●							19.0 – 21.0	(w)
Groundwater/Aquifer Remediation	●	(x)	●	●	●						20.0	(y)
Matching Quality to Use			●	●							0.08	(z)
Pollution Prevention				●			●				15.0	(aa)
Urban Runoff Management			●	●		●	●					(bb)
Resource Stewardship												
Agricultural Lands Stewardship	●	(cc)		●		●	●				5.3	(dd)
Economic Incentives (Loans, Grants, and Water Pricing)	●	(ee)	●				●					(ff)
Ecosystem Restoration							●		●		7.5 – 11.25	(gg)
Floodplain Management						●	●		●		0.48	(hh)
Recharge Area Protection		(ii)	●	●						●		(jj)
Urban Land Use Management				●			●					(kk)
Water-Dependent Recreation									●		0.02	(ll)
Watershed Management				●		●	●				0.48 – 3.6	(mm)
Other Strategies	Objectives Vary by Strategy (See Narrative)											
Essential Support Activities to Integrate Strategies and Reduce Uncertainty												
Regional Integrated Resource Planning & Management											0.25	(nn)
Statewide Water Planning											0.12	
Data & Tool Improvement											0.25	
Research & Development											0.25	(oo)
Science											3 – 5% of total	(pp)

Notes for Strategy Investment Options Table

General Notes for Potential Water Supply Benefits by 2030 (shown in Column 2)

The ranges shown in Column 2 are estimates for potential demand reduction, redistribution of supply, and supply augmentation based on a review and aggregation of available information from existing studies.

Supply estimates may not be additive because various strategies can compete for the same water. For example, new surface storage may compete for the same water that could be used by conjunctive management strategies. The estimates may not be comparative because the estimates were derived from numerous studies based on different assumptions and data sources, as described below in Specific Notes (a) – (kk). In some cases, the values represent a local or regional benefit and may not provide statewide benefits. For example, water transfers that derive supply from land fallowing can redistribute water (i.e., change of use of existing supplies) that may serve as additional supply from a local or regional perspective, but would not augment supplies from a statewide perspective. In addition, implementing some strategies, like water dependent recreation or ecosystem restoration may increase total water demands.

Specific Notes (a) – (pp):

(a), (b) Agricultural Water Use Efficiency – <u>Reduce demand</u>. Bay-Delta Program estimates for 2020 level of demand and Bay-Delta Program Solution Area only. This does not include Imperial Irrigation District water transfer. Subject mater experts are developing statewide estimates. Water savings estimates are from CALFED Ag WU Efficiency Technical Appendix and Colorado River Quantification Settlement Agreement.

The cost estimates are derived from potential on-farm and district wide efficiency improvements associated with “real water savings”. Details of estimates and assumptions are in the CALFED WUE Program Plan (Final Programmatic EIS/EIR Technical Appendix- July 2000). Water savings and associated costs for All American Canal and Coachella Branch Canal lining are not included in the cost analysis.

(c), (d) Urban Water Use Efficiency – <u>Reduce demand</u>. 1) Bay Delta Program (2000) Net Water Estimates; and 2) Pacific Institute end use study (2003). Cost estimate in progress by staff.

(e) Conveyance – Cost estimated = $1.125 billion, as follows:

($1 billion for CALFED Delta conveyance improvements) + ($125 million for Lining of the All American and Coachella canals) = $1.125 billion total cost.

(f), (g) System Reoperation – <u>Augment supply or redistribute water</u>. Supply benefit is based on future implementation of the Bay Delta Program’s Environmental Water Account from willing sellers reoperating local and regional surface water projects. Implementation of other resource management strategies will often result in system reoperation.

(h), (i) Water Transfers – Supply benefits associated with water transfers come from implementing other resource management strategies, in particular, agricultural water use efficiency, system reoperation, conjunctive management, and temporary land fallowing (included in agricultural lands stewardship). Cost estimate in progress by staff.

(j), (k) Conjunctive Management & Groundwater Storage – <u>Augment supply</u>. Conjunctive Management – The supply benefits were derived from: 1) Proposition 13 Groundwater Storage Applications to DWR for fiscal year 2001-2002; 2) Association of Groundwater Agencies report entitled, "Groundwater and Surface Water in Southern California" (2000); 3) Natural Heritage Institute report entitled, "Feasibility Study of a Maximal Program of Groundwater Banking" (1998); 4) U.S. Army Corps of Engineers report entitled, "Conjunctive Use for Flood Protection" (2002); 5) Natural Heritage Institute report entitled, "Estimating the Potential for In-Lieu Conjunctive Management in the Central Valley" (2002). Cost estimates are extrapolated from Proposition 13 Groundwater Storage Applications to DWR for fiscal year 2001-2002. Cost estimates assume that the supply benefit is not restricted by Delta export constraints or conveyance capacity.

(l), (m), (n), (o) Desalination – <u>Augment supply</u>. Information and data are from "DWR October 2003 report "Water Desalination - Findings and Recommendations", California Coastal Commission's 2003 draft report "Seawater Desalination and the California Coastal Act" and a DWR Desalination Database based on reports and articles in newspapers, newsletters, technical journals and trade journals." Primary information sources for the database are "Water Desalination Report" (weekly newsletter), International Desalination Association's Worldwide Desalting Plants Inventory series (issued biennially since 1970), "International Desalination & Water Reuse Quarterly" and California Water News, DWR’s daily compilation of water news in California.

(p), (q) Precipitation Enhancement – <u>Augment supply</u>. DWR staff analysis (2004).

Cost estimated = $.2 billion, as follows: ($7 million/year for cloud seeding activities) x (25 years until 2030) + ($2 million for initial environmental studies) = $177 million.

(r), (s) Recycled Municipal Water – <u>Augment supply</u>. *Water Recycling 2030*; Recycled Water Task Force (2003).

(t), (u) Surface Storage - CALFED – Augment supply. Bay-Delta Program Storage Investigations staff (2003). Cost estimate based on DWR and U.S. Bureau of Reclamation report entitled, “California Bay-Delta Surface Storage Program Progress Report,” April, 2004.

(v) Surface Storage – Regional/Local – No statewide cost estimates available.

(w) Drinking Water Treatment & Distribution – Cost estimate based on a formal needs survey by the U.S. Environmental Protection Agency.

(x), (y) Groundwater/Aquifer Remediation – Supply augmentation by 2030 could be as high as 1 MAF per year if aquifers not presently being used are tapped. [1] Estimated investment by 2030 would be 20 billion dollars.

[1] Groundwater that is presently being treated may continue to require treatment before use in 2030, and other current sources of groundwater may require treatment in the future. These sources are already a part of the supply, so there may be no net “supply augmentation.” Nevertheless, remediation is required to maintain existing supplies.

(z) Matching Water Quality to Use – Cost estimate based on CALFED estimates.

(aa) Pollution Prevention – Cost estimate based on a formal needs survey by the U.S. Environmental Protection Agency.

(bb) Urban Runoff Management – Cost estimates are included under Pollution Prevention. See note (o) above.

(cc), (dd) Agricultural Lands Stewardship – Redistribute water. Potential supply benefits from temporary land fallowing or permanent land retirement.

Cost estimate = $5.3 billion, determined as follows:

Total cost is the sum of three components: (A) financial assistance, (B) technical assistance and (C) land acquisition.

A: USDA estimate of unmet need for its conservation cost-share programs = ($80 million/yr) X (25 yr until 2030) = $2 billion;

B: USDA estimate of unmet need for field staff = (800 persons) X ($90,000/yr/person) X (25 yr until 2030) = $1.8 billion

C: conservation easements on about 9% of 11.4 million total acres of farmland = (1 million acres) X $1500/acre = $1.5 billion

A + B + C = $2 billion + $1.8 billion + $1.5 billion = $5.3 billion.

(ee), (ff) Economic Incentives (Loans, Grants, and Water Pricing) – Supply benefits obtained indirectly by providing incentives for changes to water management behavior by agencies and individuals. Program administration cost is the only direct cost.

(gg) Ecosystem Restoration – Cost estimate = $7.5 –11.25 billion, as follows:

($150 million/year for CALFED activities) X (25 years until 2030) = $3.75 billion for CALFED area.

($3.75 billion) X (an expansion factor of 2 or 3 to cover areas outside CALFED) = $7.5 –11.25 billion

(hh) Floodplain Management – Cost estimate = $475 million, as follows:

($57 million for Flood Protection Corridor Program, disbursed over 3 years) = ($19 million/yr) X (25 years until 2030) = $475 million

(ii), (jj) Recharge Area Protection – The water supply benefit and associated cost is included in the strategy, conjunctive management and groundwater storage.

(kk) Urban Land Use Management – No statewide cost estimates available.

(ll) Water-Dependent Recreation – Cost estimate considers construction of 4, 100-site campgrounds, at $3.5 million each.

(4 campgrounds) x ($3.5 million/campground) = $14 million

(mm) Watershed Management – Costs for planning, communication, and decision making processes for local and regional watershed management efforts. Assessments, planning functions, public decision-making forums are the focus of most of the expenditures.

Period (years)	Assessment-Planning [2] ($ million)	Public Process [3] ($ million)	Projects [4] ($ million)	Total for period
2004-2009	$10-37.5	$8-16	$14-80	$160 - 667
2010-2015	$10-30	$8-16	$14-88	$160 - 804
2016-2030	$10-25	$8-16	$14-100	$160 – 2,115
Total				$480 – 3,586

[2]Assessment/Planning: From CALFED Finance Plan:
Annual cost 2004 period
Assessment and Planning $4-15 million,
Public Process $2-4 million, (listed as technical assistance in Finance Plan)
Annual cost 2010 period
Assessment and Planning $4-12 million
Public Process, $2-4 million
Annual cost 2016 period
Assessment and Planning $4-10 million
Public Process, $2-4 million

[3] The CALFED service area represents a portion of the State. For Assessment and Planning, the service area is estimated as 40% of statewide need and for Public Process as 25% of statewide need. Therefore, statewide Assessment and Planning = 2.5 x CALFED value, and Public Process = 4 x CALFED value.

[4] For Projects, CALFED service area is estimated to be 25% of the statewide need.

(nn) Regional Integrated Planning & Management – Assumes $1 million per hydrologic region per year.
($.001 billion/hydrologic region/year) x (10 hydrologic regions) x (25 years) = $250 million

(oo) Research & Development – Assumes $10 million per year for 25 years.
($.010 billion/year) x (25 years) = $250 million

(pp) Science – Costs for supporting science programs are assumed to be 3 to 5 percent of total implementation costs.

Agricultural Lands Stewardship

Agricultural lands stewardship broadly means conserving natural resources and protecting the environment by compensating owners of private farms and ranches, in production, to implement stewardship practices. Agricultural lands stewardship also protects open space and the traditional characteristics of rural communities. Moreover, it helps landowners maintain their farms and ranches rather than being forced to sell their land due to pressure from urban development. For this paper, "agricultural lands stewardship" means farm and ranch landowners – the steward's of the state's agricultural lands – producing public "environmental goods" in conjunction with the food and fiber they have historically provided while keeping land in private ownership.

This strategy is focused on agricultural land (cropped and grazed land) as defined by the California Land Conservation (Williamson) Act. Other resource-based land uses, such as forestry and mining, are addressed by the Watershed Management strategy later in this volume. Agricultural land stewardship can take place on a particular parcel of land, on multiple parcels in one landowner's possession, or in an integrated manner on agricultural lands regionally or statewide. The goal of this approach is to promote sustainable agricultural practices with an economic return, while managing these productive lands for multiple benefits, including water management improvements. The following box shows examples of agricultural lands stewardship practices.

Examples of Agricultural Lands Stewardship Practices

- Wetland Restoration - Wetland acreage improves water quality by filtering out pollution and sediments. It also helps flood management by slowing the flow of water. Healthy wetlands are indispensable for recharging underground aquifers and providing specific wildlife habitat.
- Shallow-Water Wildlife Areas - Shallow water areas provide habitat and water for wildlife. Temporary rice field habitat also provides resting and feeding grounds for waterfowl and shorebirds and related terrestrial species. Rice field flooding speeds the decomposition of rice straw, reduces air pollution, improves soil fertility and helps with the decomposition of agricultural chemicals.
- Windbreaks – Rows of trees or shrubs along field boundaries help control soil erosion, conserve soil moisture, improve crop protection, provide livestock shelter and wildlife habitat, reduce drainage water, and increase carbon sequestration (removal of carbon dioxide from the atmosphere).
- Irrigation Tailwater Recovery – Collection, storage and transportation facilities help capture and reuse irrigation runoff water to benefit water conservation and off-site water quality. [See the Agricultural Water Use Efficiency strategy]
- Filter Strips, Grassed Waterways, Contour Buffer Strips – These are practices to reduce erosion and provide water quality protection, with some wildlife benefits depending on management.
- Conservation Tillage – Soils tillage increases water infiltration and soil water conservation, reduces erosion and water runoff, sequesters carbon, and improves soil ecosystem and habitat quality.
- Noxious Weed Control – This practice establishes self-sustaining populations of "control organisms" to control or prevent weed infestations.
- Riparian Buffers - Areas of trees, shrubs, and grasses adjacent to streams or drains help filter runoff by trapping sediments, nutrients, and pesticides. Riparian buffers also provide wildlife habitat.
- Livestock Access – This practice restricts or controls livestock access to surface waters to reduce sediment and nutrient nonpoint source pollution.

Land Retirement and Land Conversion

In some cases, choices are made that permanently remove land from agricultural use and from private ownership. Public acquisition of the land for nonagricultural uses is one example. In addition, land conversion occurs where landowners voluntarily choose to sell their property for urban development (see the Urban Land Use Management strategy). In this context, neither land retirement nor land conversion are stewardship practices.

There are many ways that agricultural lands can be profitably managed. Under some circumstances, temporary land fallowing (temporarily stopping irrigation for a season or more) on a selective basis may be a stewardship practice depending on site-specific conditions, and landowner and community interests. For example, temporary land fallowing, sometimes called crop-idling, is a drought response or water banking strategy for which DWR and others have provided financial compensation to participating landowners. Land fallowing is also an agronomic practice to benefit the soil or for other management purposes. Payments to farmers could be used on farm-related investments, purchases and debt repayment, or may be spent or invested outside the community.

In some areas, stopping irrigation on a permanent basis may be considered for farmlands with drainage problems related to soils that are not well-suited for irrigation. The risk of selenium exposure to fish and wildlife is reduced when irrigation on land in the drainage problem areas is permanently stopped. This reduction in drainage water will reduce the volume that needs disposal and may reduce downstream pollution. These lands provide opportunities to allocate water to other agricultural lands. The land could be support other beneficial uses such as grazing and dry land farming (see Rainfed Agriculture in the Other Strategies section of Volume 2). The lands also may be managed as upland habitat or wildlife refuges, depending on the goals and terms of the conservation easements.

Integrated on-farm drainage management (IFDM) can be use to protect and enhance farmland, wildlife and water resources in drainage problem areas. The goal of IFDM is to eliminate the need for discharging subsurface drainage water from farms into waterways or evaporation ponds. The IFDM system manages irrigation water on salt-sensitive high value crops and reuses subsurface drainage and tailwater on increasingly salt-tolerant crops. Biological filters, drainage and tail water systems, crop management and salt harvesting in an evaporation system improve water use efficiency, provide for the use of concentrated drainage water, and eliminate the need to dispose of agricultural drainage water. This approach to the management of agricultural lands affected by saline water and perched water tables has primarily been used on the west side of the San Joaquin Valley. It offers an alternative to retirement of agricultural lands.

Current Agricultural Lands Stewardship Initiatives

Agricultural lands stewardship is not a new concept. Under various names, it has been practiced and encouraged by the United States Department of Agriculture (USDA) through the Natural Resource Conservation Service (NRCS) and various non governmental entities for many years. The California Resource Conservation Districts (RCDs), and other entities, specialize in working with private landowners in watershed management and coordination strategies. Since governmental land acquisition programs can only affect a small portion of agricultural lands, stewardship is increasingly considered by governmental and nongovernmental organizations for protecting natural resources while keeping the lands in productive private ownership.

A range of private and public programs and initiatives already exist which fit the stewardship model (see following box). Many public programs provide technical assistance on what crops to plant, and how to plant, cultivate and irrigate them. Other technical assistance includes advise on friendly farming techniques for wildlife and aquatic ecosystems. Additional types of programs cover soil, water, and habitat conservation planning. These efforts can identify suitable areas for farming and habitat management. Urban planning programs can also be used to avoid agricultural land fragmentation and permanent loss of valuable agricultural land due to urban development (see the Urban Land Use Management strategy). And finally, there are programs which limit or cease commercial agricultural use to promote wetlands and other wildlife sensitive areas, while keeping lands in private ownership and stewardship.

Initiatives that Exemplify Agricultural Lands Stewardship Strategy

- Proposition 50 Ecosystem Restoration Program's Proposed Working Landscapes Grants. Allocated not less than $20 million dollars "for projects which assist farmers in integrating agricultural activities with ecosystem restoration." These funds could be used as "matching funds" with the Farm Bill, thus leveraging state money with federal resources.
- US Natural Resources Conservation Service's (NRCS) New Conservation Security Program. Offers incentives and rewards to growers who implement resource conservation plans for parts or all of their lands. The USDA Federal Wetland Reserve Program (WRP), Conservation Reserve Program (CRP) and the Grasslands Reserve Program (GRP) offer incentives for each acre set aside. Wildlife Habitat Incentives Program (WHIP) provides up to seventy-five percent cost-share to reimburse participants for installing practices beneficial to wildlife.
- CA Department of Water Resources (DWR) Flood Protection Corridor Program. Grants for nonstructural flood management that enhance wildlife habitat and/or protect agricultural uses on private lands.
- CA Department of Fish & Game (DFG) Private Lands Management Program. Offers ranchers and farmers an opportunity to increase their income by improving habitat for wildlife through fishing and hunting.
- CA Wildlife Conservation Board Rangeland, Grazing Land & Grassland Protection Act of 2002. Grants to prevent rangeland conversion to more intensive uses, and to improve grazing and wildlife.

The following three examples describe a range of stewardship programs including an active stakeholder process, a federal incentives program, and a statutory "land retirement" program.

The CALFED Working Landscapes Subcommittee

The Bay-Delta Public Advisory Committee (BDPAC) established a Working Landscapes Subcommittee to advise the BDPAC in the formulation of a working lands management approach for Bay-Delta Programs. The Working Landscape Subcommittee seeks to provide the BDPAC with creative and practical strategies that: (1) enhance the sustainability of California agriculture; and (2) provide for participation of local communities, landowners and managers; while, (3) significantly contributing to the fulfillment of and in accordance with the CALFED Record of Decision to restore ecological health and improve water management for beneficial use of the Bay-Delta system while minimizing impacts to agriculture.

The Farm Security and Rural Investment Act of 2002

The reauthorized national Farm Bill 2002 provides several new and traditional agricultural conservation programs that exemplify an agricultural lands stewardship strategy. All programs are voluntary and include technical assistance, financial incentives, and both temporary and permanent set-aside payments for various purposes.

BDPAC Working Landscapes Approach

The working landscape is defined as an economically and ecologically vital and sustainable landscape where agricultural and other natural resource-based producers generate multiple public benefits while providing for their own, and their communities', economic and social well-being.

Central Valley Project Improvement Act Land Retirement Program

One of the provisions of the 1992 Central Valley Project Improvement Act authorized purchase, from willing sellers, of agricultural land and associated water rights and other property interests which receive Central Valley Project (CVP) water. All lands selected for retirement will likely be located south of the Sacramento-San Joaquin Delta, in locations where drainage conditions and water quality are poor. The program is expected to retire a total of about 100,000 acres of irrigated farmland.

The U.S. Bureau of Reclamation (Reclamation), in partnership with the U.S. Fish and Wildlife Service and the U.S. Bureau of Land Management, are the responsible Federal agencies for implementing the CVPIA Land Retirement Program. These agencies initiated the Land Retirement Demonstration Act to address concerns about the scope and degree of potential impacts of retirement on wildlife, drainage volume reduction, socio-economic impacts, and the overall cumulative effects of changing irrigated lands to non-irrigated use.

Potential Benefits

Agricultural lands stewardship can be included as an integral component of regional integrated resource planning, including watershed planning and implementation. Agricultural lands stewardship can use best management practices to protect the health of environmentally sensitive lands, improve water quality, provide water for wetland protection and restoration, and aid riparian reforestation and management projects. Lands can also be managed to improve water management, urban runoff control, water storage, conveyance and for groundwater recharge. These best management practices are attractive since they don't rely on construction of major facilities.

Agricultural land stewardship can be part of a regional strategy of growth management. Agricultural lands provide public benefits for floodplain management, scenic open space, wildlife habitat, and defined boundaries to urban growth. Stewardship provides the rural counterpart to urban efforts to encourage more water efficient development patterns of land use. It also can minimize fragmentation of agricultural lands by development that can decrease productivity and harm the ecosystem.

Potential Costs

Agricultural lands stewardship is a cost-effective way to sustain our agricultural land base while accomplishing complementary objectives. Three questions must be asked in determining potential costs: 1) What are the direct costs for supporting stewardship programs? 2) What are the common cost measurements for a wide spectrum of environmental values? 3) What current level of investment is needed to anticipate future needs and their costs?

Developing stewardship costs is similar to estimating costs of managing lands to avoid environmental impacts such as air and water pollution, or to provide wildlife habitat or secure food and fiber production. Stewardship is a way of doing business and it should be a part of an economic model that places a value on healthy communities (quality of life). In addition, agricultural lands stewardship helps avoid costs associated with urban land use. Not only are there cost savings by avoiding expansion of infrastructure, but there are avoided costs for flood damage reduction measures and urban runoff.

Annual costs of managing the lands to avoid environmental impacts need to be quantified. Any program that stops irrigation will have to provide for the cost of establishing permanent vegetative cover that is appropriate to the area, sometimes using temporary irrigation. In many cases this may be a significant start-up cost and will also require maintenance. Additional costs may include program development, administration, and mitigation of local and regional socio-economic impacts.

Despite interest in programs that temporarily or permanently stop irrigation, relatively little comprehensive analysis has been completed on the cost-effectiveness of these programs. In one study, Stroh (1991) compares the costs of meeting drainage goals through five drainage management schemes: stopping irrigation, treatment, evaporation, dilution, and ground-water pumping. Findings suggest that stopping irrigation can be a cost-effective solution to meeting a drainage objective, but only under a limited set of conditions (such as high selenium in soils which makes drainage solutions expensive).

Experience suggests that many California agricultural lands owners may participate in some agricultural lands stewardship programs if the annual rents they receive are in the $100 to $200 per acre range. A new Farm Bill Conservation Security Program is intended to pay the landowner an annual payment for conservation benefits identified in their conservation plans. Annual payments are estimated for each qualified landowner to range up to $45,000 per year.

Major Issues Facing an Agricultural Lands Stewardship

There are major issues related to improving agricultural lands stewardship in California.

Landowner Concerns

Landowners are concerned that environmental programs that help growers improve habitat may create species' taking by attracting rare, threatened and endangered species. Thus some landowners are reluctant to be involved with government agencies, even though some of these agencies may provide assistance to help compliance with real regulatory requirements.

Although many landowners request "safe harbor" assurances for voluntary local programs, Federal Endangered Species Act (FESA) assurances can only be granted by the US Fish Wildlife Service and the National Marine Fisheries Service. In order to determine what type of species must be covered and possible protective measures which may be required, surveys are necessary to determine what species are present. This only increases landowner concerns that they will be subject to increased restrictions if the presence of endangered species is verified on their property.

Some landowners question how they can adequately maintain their privacy and, at the same time, satisfy the public need for transparency of farm activities supported by public resources and certainty, when they participate in voluntary programs designed to meet regulatory goals and standards. In addition, there is landowner confusion regarding what type of "assurances" can be provided. A common landowner perspective is that the economic return from certain land stewardship programs may often be less than the return from other options for land use, especially when urban development is an option.

Lack of Information

There is a lack of scientific economic, social and environmental studies and monitoring of agricultural lands stewardship programs to evaluate their merits for ecosystem restoration, water quality, and agricultural economics for large and small agricultural operations. There are conflicting reports about the compatibility of certain agricultural lands stewardship and ecosystem restoration programs, in part because the management to assure compatibility must be tailored to local circumstances and then monitored and assessed. In order to justify public investment in stewardship, there must be accountability in terms of monitoring.

Complex Regulations and Programs

Institutional regulations and programs are a complex maze and sometimes in conflict. Agricultural landowners may be discouraged when developing a stewardship program that is crosscutting and encompassing water and soil conservation with ecosystems restoration, floodplain and wetlands management, water quality and land use planning. The regulations may seem intrusive to the private landowner but essential for those responsible for environmental protection and restoration programs.

Funding

California has traditionally received proportionally less funding for USDA Farm Bill's conservation provisions overall relative to its agricultural standing, the value of the threatened resources and the population served. California is dominated by specialty crops rather than traditional price-supported "Program" that receive most conservation programs money in other states. The funding inequities of the Farm Bill will become increasingly apparent in the future as production of California cotton, alfalfa, irrigated pasture, and possibly rice decreases and as specialty crops increase.

Regional cooperation

Without regional cooperation on regional issues, private landowners may be frustrated in their management goals by adjacent operations or watershed activities that do not contribute to better management for environmental functions and values. These values include protecting and reestablishing riparian corridors or water quality within a watershed.

Reports on Land Retirement Do Not Agree

Existing reports on land retirement do not agree about the extent, if any, of the loss of agricultural productivity, loss of revenue to the local communities, loss of a way of life, and regional and statewide socio-economic effects. There may be additional maintenance costs to mitigate, or to avoid, environmental impacts. Specific soil stabilization and crop management may be required if the lands continue to be farmed without irrigation. Stopping irrigation may have effects on neighboring agricultural lands, including introduction of new wildlife species, weeds, pests, illegal dumping of refuse, complication of water and water rights issues, and alteration of physical resources such as soils, groundwater, surface waters. Stopping irrigation may result in water applications for urban use out of the area.

There are concerns whether stopping farmland irrigation on a temporary or permanent basis may have an adverse effect on the local tax base, community businesses and farm related jobs, especially when labor and other services have a large percentage of low income and disadvantaged groups. Some have suggested that if a significant amount of land is retired it may also have a statewide influence on the tax bases, economies, and food production and security. On the other hand, others have provided information that suggests larger, external forces may be the primary influence on these negative trends in agriculture.

State Policy Goals

There is the tension between state and local control. In general, land use is a local planning issue subject to local regulation. Statewide planning goals or restrictions may be seen as an intrusion on local governmental powers. Second, is the tension between private goals and public commitments. Many landowners prefer programs such as the Williamson Act because these are temporary land use restrictions which landowners can ultimately “opt out’ of if they later decide to sell land to development and the asking price justifies the cancellation penalty. As a result, many landowners are wary that they may lose future economic opportunities by committing to permanent restrictions. Likewise, the public may be unwilling to fund the necessary incentive (rental, technical assistance, etc.) programs essential to successful stewardship without a clear understanding of long-term benefits from such programs.

Recommendations to Facilitate Working Lands Stewardship

The following recommendations can help facilitate an agricultural lands stewardship strategy:

1. The state should collaborate with rural and agricultural organizations and coordinate with local RCDs to provide private landowners financial incentives and access to educational resources through appropriate public and nongovernmental programs that explain and demonstrate the benefits of agricultural lands stewardship and ecosystem restoration.
    - Demonstrate that stewardship programs can help landowners be good stewards without compromising landowner rights.
    - The program should emphasize that it is voluntary, flexible, and incentive-based strategy.
    - Provide “success” stories to resource managers and environmental organizations to demonstrate that private stewardship can achieve desired environmental benefits.
    - Provide economic information regarding the advantages and disadvantages of land stewardship to compare with other investment choices.
2. The state should create a directory that identifies the appropriate state agency for coordination, implementation. These agencies should provide staff support for landowners participating in multiple environmental goals and local conservation initiatives. Among other, these should include the Department of Conservation’s Watershed Coordinator, Natural Resource Conservation Service programs, Resource Conservation Districts cooperative program, and other programs. The agency should identify opportunities to further institutional coordination, assist landowners in applying for grant funding, and facilitate multiple stakeholder planning and implementation.
    - Ensure consistent, dependable and adequate funding for stewardship assistance, especially the USDA Natural Resources Conservation Service, the agency that has traditionally provided this kind of assistance.
    - Assist landowners with endangered species issues.
    - Document environmental results with accepted standards, criteria and protocol while respecting private land ownership.

3. The state should help landowners implement agricultural lands stewardship plans. Greater state participation would help direct federal funds toward landowner participation and technical assistance.
4. The state should evaluate the socio-economics effects of agricultural lands stewardship, including a comprehensive assessment of:
   - Regional changes in agricultural production inputs and farm income (including income received from land and water payments) as the result of temporary land fallowing or permanent stopping of irrigation
   - "True cost accounting" – costs and benefits over long-term and including maintenance - for stewardship management approaches
   - Habitat restoration (including financial on-farm investments and increased recreational opportunities)
   - Annual maintenance expenditures

   Use the evaluation as guidance for maintaining the economic stability of local community continuity, including potential reductions in jobs, tax base, and community and commercial production.
5. The state should increase scientific studies to assess the environmental, ecosystem restoration and agricultural benefits of agricultural lands stewardship programs. The state should continue research on sustainable agriculturally-based economies. The state should continue monitoring and assessing positive and negative effects of habitat restoration, temporary fallowing and permanent stopping irrigation, including improved air and water quality and associated costs.

Information Sources

- Private Lands, Public Benefits, Principles for Advancing Working Lands Conservation, National Governors Association/Center for Best Practices www.nga.org
- Stewardship America www.privatelands.org
- CA Department of Food and Agriculture www.cdfa.ca.gov
- EPA National Agricultural Compliance Center www.epa.gov

Agricultural Water Use Efficiency

Agricultural water use efficiency efforts involve improvements in technologies and/or management of agricultural water that result in water savings, benefit water supply, water quality, or the environment. This narrative discusses some efficiency improvements, such as those to irrigation equipment, crop water management, farm water management, and district distribution systems.

Current Agricultural Water Use Efficiency Efforts in California

Agriculture is an important element of California's economy, generating $27.6 billion in gross income in 2001, according to the California Agricultural Statistics Service. In 2000, California irrigated an estimated 9.6 million acres of cropland with about 33.7 million acre-feet of applied water.

In California, many growers and irrigation districts have implemented state-of-the-art design, delivery, and management practices to increase production efficiency and conserve water. As a result, they have made, and continue to make, great strides in increasing the economic value and efficiency of their water use. One indicator of agricultural water use efficiency improvement is that agricultural production per unit of applied water (tons/acre-foot) for 32 important California crops increased by 38 percent between 1980 to 2000. Another indicator is that inflation-adjusted gross crop revenue per unit of applied water (dollars/acre-foot) increased by 11 percent between 1980 and 2000.

The Agricultural Water Suppliers Efficient Water Management Practices Act of 1990 (AB 3616) and the Federal Central Valley Project Improvement Act (CVPIA) established a framework for improving agricultural water use efficiency. Presently, the Agricultural Water Management Council unites, through a Memorandum of Understanding (MOU), agricultural water suppliers in an effort to improve water use efficiency through implementation of efficient water management practices (EWMPs). The Council recognizes and tracks agency water management planning and implementation of cost effective EWMPs through a review and endorsement procedure. The agricultural water suppliers who are signatory to the MOU, have voluntarily committed to implement locally cost effective EWMPs (see side bar on following page). They represent more than 3.8 million acres of irrigated agricultural land (retail water suppliers) statewide (equivalent to 5.2 million acres of wholesale water agencies.) Some signatories to the MOU have submitted WMPs, most of which have been endorsed. Additionally, 24 signatories subject to federal CVPIA planning requirements have plans that have been endorsed by the Council.

Growers invest in on-farm water management improvements to stay economically competitive. Likewise, local irrigation and water agencies invest in cost-effective system-wide water management improvements. In addition to water savings, implementation of efficiency measures may provide water quality and flow timing benefits. CALFED has identified a set of Quantifiable Objectives (QOs) – numeric targets of water savings, water quality and flow timing benefits – to meet CALFED goals for agriculture. Targeted QOs may be local, regional, and/or statewide. As such, state and federal programs may provide funding for EWMPs that are not locally cost effective and for actions other than the EWMPs.

Substantial financial support for research, development and the demonstration of efficient water management practices in agriculture has come, and continues to come, from the agricultural industry. Support also comes from the early adopters of new technology who often risk their crops, soils and dollars when cooperating to develop and demonstrate technology innovations. Further investments in

Agricultural Water Management Efficient Water Management Practices (EWMPs)

List A - Generally Applicable Efficient Water Management Practices Required of all Signatories of Agricultural MOU

1. Prepare and adopt a Water Management Plan
2. Designate a Water Conservation Coordinator
3. Support the availability of water management services to water users
4. Where appropriate, improve communication and cooperation among water suppliers, water users, and other agencies
5. Evaluate the need, if any, for changes in policies of the institutions to which water supplier is subject

List B - Conditionally Applicable Efficient Water Management Practices – Practices Subject to Net Benefit Analysis and Exemption from Analysis

1. Facilitate alternate land use (drainage)
2. Facilitate use of available recycled water that otherwise would not be used beneficially
3. Facilitate the financing of capital improvements for on-farm irrigation systems
4. Facilitate voluntary water transfers that do not unreasonably affect the water user, water supplier, the environment, or third parties
5. Line or pipe ditches and canals
6. Within operational limits, increase flexibility in water ordering by, and delivery to, the water users
7. Construct and operate water suppliers spill and tail water recovery systems
8. Optimize conjunctive use of surface and groundwater
9. Automate canal structures

List C - Practices Subject to Detailed Net Benefit Analysis without Exemption

1. Water measurement and water use report
2. Pricing or other incentives

For detailed information on the Agricultural Water Management Planning and Implementation process, implementation of EWMPs, Net Benefit Analysis and schedules, see the Memorandum of Understanding at AWMC Web site. www.agwatercouncil.org/aboutusmain.htm

research and demonstration are critical, especially in support of university-based research, field station studies, and cooperative extension demonstration projects.

Improvements in the efficiency of agricultural water use result primarily from efforts in three areas:

- **Hardware –** Improving on-farm irrigation systems and district water delivery systems
- **Water management –** Improving management of on-farm irrigation systems and district water delivery systems
- **Crop water consumption –** Reducing crop evapotranspiration

Hardware Upgrades

Due to system limitations, growers are often unable to apply the exact amount of irrigation water when the crop needs it. Water system improvements such as integrated supervisory control and data acquisition systems (SCADA), canal automation, regulating reservoirs, and other hardware and operational upgrades, can provide flexibility to deliver the water when and where it is needed in the appropriate quantities. Most orchards and vineyards, as well as some annual fruits and vegetables in the state, are irrigated using pressurized irrigation systems. Almost all trees and vines established since 1990 are irrigated using micro-irrigation. Between 1990 and 2000, acreage with micro-irrigation in California grew from 0.8 to 1.9 million acres, a 129 percent increase. (see the following table).

Trends in Irrigation Method Acreage (in million acres)

Irrigation method	1990		2000		% change
	Acreage	%	Acreage	%	(in Acreage)
Gravity (furrow, flood)	6.5	67.5	4.9	51.3	- 16.2
Sprinkler	2.3	23.8	2.8	28.8	5.0
Drip/micro	0.8	8.7	1.9	19.9	11.2
TOTAL	9.6	100	9.6	100	

Source: DWR

Example Irrigation Efficiency Improvement

Kern County Water Agency reports significant improvements in irrigation efficiency. An analysis of data in 1986 compared to 1975 showed an 8 percent improvement (from 67 percent in 1975 to 75 percent in 1986). This improvement reduced the total applied water use in the San Joaquin Valley portion of Kern County by about 250,000 acre-feet, enough water to irrigate about 70,000 acres. Since 1986 Kern County has added 61,500 acres of trees and vines. These now make up 37 percent of the total irrigated acreage. Nearly all of this new acreage has low volume drip irrigation systems installed. KCWA estimates the overall on-farm water use efficiency now is about 78 percent.

Many growers use sophisticated automated irrigation systems for irrigation, fertilizer application, and pest management. Advanced technologies used include Geographic Information System (GIS), Global Positioning System (GPS) and satellite crop and soil moisture sensing systems. Satellite-based technologies allow growers to improve the precision of their water application
The shift to pressurized irrigation systems, sprinkler, drip and micro-spray, often requires modernization of the district water delivery systems to provide irrigation water on-demand. Increasingly, irrigation districts are upgrading and automating their systems to enable precise, flexible, and reliable deliveries to their customers. Districts are also lining canals, developing spill recovery and tail water return systems, employing flow regulatory reservoirs, improving the efficiency of pumps, and implementing conjunctive water use programs. With the advancement of irrigation systems and related technologies, there is a potential to improve irrigation efficiencies at both on-farm and district levels.

Growers have made and continue to make significant investments in on-farm irrigation system improvements (e.g., lining head ditches, using micro-irrigation systems). In terms of future improvements, the Cal Poly Irrigation Training and Research Center (ITRC) estimates that an additional 3.8 million acres could be converted to precision irrigation such as drip or micro-spray irrigation. While this may not reduce crop water demand, it could improve the distribution uniformity of water applied, reduce non-beneficial evaporation, and thus allow the grower to apply less water to the field. Research on drip irrigation of alfalfa has shown water application reduction at two to three percent with yields increasing from 19 to 35 percent, an increase in productivity of 30 percent with the same amount of applied water. Conversion of traditional irrigation systems to pressurized systems and installation of advanced technologies on district delivery systems require additional investments in equipment and structure as well as use of additional energy which increases farm production costs and district operational costs.

Water Management

Both on-farm and district systems must be managed to take advantage of new technologies, science, and hardware improvements. Personal computers connected to real-time communication networks and local area networks allow transmission of data from flow sites to a centralized location. These features enable district staff to monitor flow, manage each flow site, and log data on a continuous basis. With such systems, district staff spends less time monitoring and manually controlling individual sites, allowing them to plan, operate the system in a strategic and integrated manner, and reduce operations costs. Such systems improve reliability of the communication systems operation for flexible water delivery, distribution, measurement, and accounting purposes.

Regulated Deficit Irrigation

Regulated deficit irrigation (RDI) is an irrigation management strategy that some growers use to stress trees or vines at specific developmental stages. The goal is to improve crop quality, decrease disease or pest infestation, reduce production costs, and reduce crop water use without reducing profits. The conventional irrigation management strategy has predominantly been to avoid crop water stress. Research on RDI began in California in the 1990's with initial results showing potential for reducing evapotrans-piration while increasing or maintaining crop profitability and allowing optimum production.

RDI is used primarily on tree and vine crops to control crop quality. On these crops, water stress imposed at specific growth stages has been found to improve crop quality even while plant growth is limited. Wine grapes are a clear example: mild stress imposed through the growing season decreases canopy growth, but produces grapes with higher sugar content, better color and smaller berries with a higher skin to fruit volume ratio.

RDI has been primarily used as a production management practice and the areal extent of its application in California has not been quantified. Before RDI can be applied to other crops, information on its costs, risks, long-term impacts, and potential benefits including water savings must be determined. Once that is done, practical guidelines for growers on how to initiate, operate, and maintain RDI should be developed and disseminated. (See Volume 4: Reference Guide for details on RDI).

Some of today's growers use satellite weather information and forecasting systems to schedule irrigation. Many growers employ evapotranspiration and soil moisture data for irrigation scheduling. Users generate more than 70,000 inquiries per year to the California Irrigation Management Information System (CIMIS), the Department of Water Resources' weather station program that provides evapotranspiration data. Universities, districts, and consultants also make this information available to a much wider audience via newspapers, websites, and other media.

Growers who irrigate by gravity employ laser leveling. The furrows, basins and borders are designed to ensure that water application meets crop water requirements while limiting runoff and deep percolation. Crops are frequently germinated using sprinkler systems. Other growers use plastic mulch to reduce non-essential evaporation of applied water. Many growers take advantage of mobile laboratory services to conduct in-field evaluation of irrigation systems. Once considered innovative technologies, these are now standard practices with growers.

Reducing Evapotranspiration

Evapotranspiration is amount of water that evaporates from the soil or transpires from the plant. A grower can reduce evapotranspiration by reducing unproductive evaporation from the soil surface shifting crops to plants that need less water, and/or reducing transpiration - see regulated deficit irrigation sidebar

Potential Benefits of Agricultural Water Use Efficiency

On-farm irrigation improvements can benefit farmers by reducing water applied, reducing groundwater overdraft, increasing crop yield, improving crop quality, lowering the cost of inputs including energy, facilitating the sale of the conserved water And may increase net profit. In the case of water transfers, growers and districts may adopt practices that would otherwise be uneconomic (See Water Transfer strategy). By implementing system improvements, districts provide better service to their customers by increasing delivery flexibility (time and amount of delivery) and reducing seepage and spills. Shifting electric load from peak to off-peak could benefit the farmer and the district by reducing energy costs.

In 2000, the CALFED Water Use Efficiency Program estimated net water savings associated with proven improved agricultural water use efficiency measures to be 120,000 to 565,000 acre-feet per year (see net water sidebar). These net water savings are based on hardware, operational regimes, and irrigation management improvements. Also, there are 47,000 acre-feet of water savings through water use efficiency efforts in the Colorado River Region resulting from the Quantification Settlement Agreement (QSA) that is not included in the CALFED estimates. Likewise, an additional savings of 67,000 acre-feet and 26,000 acre-feet can be achieved by lining the All American Canal and Coachella Branch Canal respectively (For details, see www.usbr.gov/lc/region/g4000/crwda/index.htm).

Applied Water and Net Water Savings

A farmer may apply water to a given field in amounts that is less than, equal or greater than crop evapotranspiration. This amount is called applied water. Often applied water is greater than crop evapotranspiration due to irrigation system inefficiencies, cultural practices, non-uniformity in irrigation hardware and distribution uniformities, and management practices to maintain salt balance in the soil root zone and prevent salinization and degradation of soil.

The water in excess of crop consumptive use or evapotranspiration ending in the salt sinks (saline ground water or ocean) and non-beneficial evaporation constitute opportunity for net water saving.

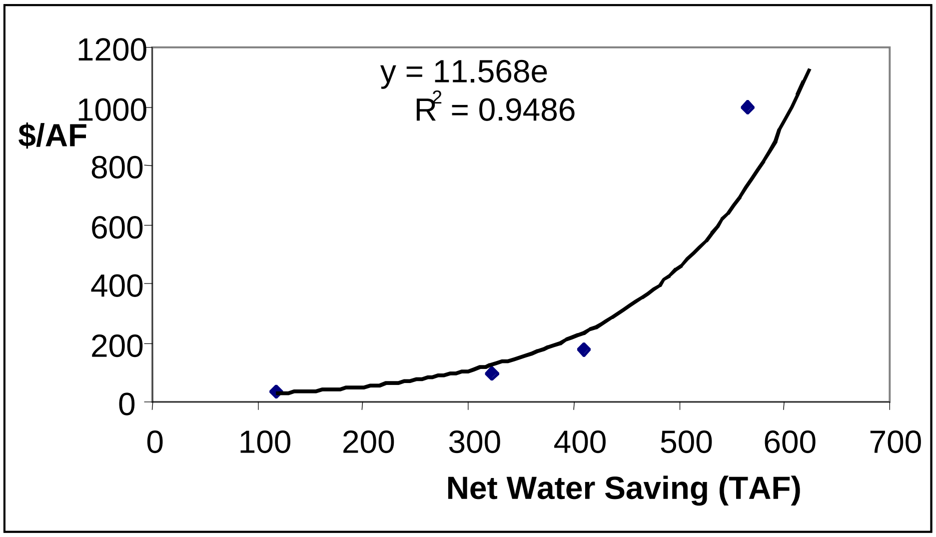
Often, reduction in applied water as a result of efficiency measures is mistaken with net water savings. In some areas, water applied to fields in excess of crop water needs flows to usable surface and groundwater systems and is reused by downstream water users. Such multipurpose reuse also provides opportunities for environmental benefits. Efficiency measures and reduction of applied water in these areas does not yield net water savings and adversely impacts downstream water users, however, it may improve water quality.

Environmental benefits can include increased stream flow and improvements in water temperature and flow timing. Environmental benefits may include water quality improvements through reduced subsurface drainage, surface runoff, and contaminant load, which help dischargers in complying with total maximum daily load requirements. However, improvements in water use efficiency on the field can cause negative environmental effects, such as reduced runoff to downstream water bodies and increased concentration of pollutants in drain water unless the drainage water contaminants are isolated and properly disposed. The CALFED Water Use Efficiency Program estimated applied water reduction (recoverable losses which currently are reused) through changing the time of diversion (rerouting) to provide flow and/or timing benefits to be 1.60 million acre-feet per year. The recoverable losses are reused with multi-benefits such as groundwater recharge, fish and wildlife habitats, and for production of food and fiber. The reduction in applied water in the form of rerouting flows doesn’t constitute net water savings.

Benefits resulting from implementation of other advanced technologies in hardware, water management, and crop evapotranspiration, crop shifts and reducing crop transpiration have not been quantified for this narrative.

Potential Costs of Agricultural Water Use Efficiency

The Water Use Efficiency Program estimated net water savings at two levels of expenditure. The first level results when growers and water districts implement efficient water management practices as a part of their standard operation. This level estimates net water savings of 120,000 to 320,000 acre-feet per year at a cost of $35 to $ 95 per acre-foot. The second level results from investment of funds by local , state and federal agencies. This is estimated to achieve additional net water savings ranging from 88,000 to 243,000 acre-feet per year at a cost of $80 to $900 per acre-foot. The cost assumes on-farm efficiency of 85 percent. These cost estimates are based on proven hardware, operation, and management. The estimated costs have a non-linear relationship with the amount of net water savings (see adjacent figure). It should be noted that the water savings and associated costs of All American Canal and Coachella Branch canal lining are not included in these cost estimates.



Implementation of other advanced technologies in hardware, water management, and reducing crop evapotranspiration as proposed in this strategy may result in savings in addition to the savings estimated by the CALFED Program. The additional improvements will increase the cost of crop production or may introduce risk. These additional savings, costs and risks have not been quantified. DWR and CBDA are presently refining the estimates of net water, applied water savings, and associated costs. It is anticipated that the revised estimates will be in the Administrative Draft of this Water Plan Update.

Major Issues Facing Additional Agricultural Water Use Efficiency

Major issues related to improving agricultural water use efficiency in California are:

Funding

Funds dedicated to water use efficiency have fallen below estimates in the 2000 CALFED Record of Decision that called for an investment of $1.5 billion to $2 billion from 2000-2007. The CALFED Framework For Agreement committed state and federal agencies to fund 50 percent (25 percent each), with local agencies funding the remaining 50 percent of CALFED water use efficiency activities. Although the need may be great, small and disadvantaged communities may not to apply for state and federal grants, because of the difficulty of the application and grant management for what are often limited funds. In addition, such districts rarely have the technical and financial abilities to develop plans or implement expensive water management practices.

For some districts, funding for water conservation comes from the ability to transfer water. While transfers to urban areas may reduce the amount of water available to grow crops and may cause third party and environmental impacts, they are expected to play a significant role in financing future water use efficiency efforts.

Implementation

Implementation of agricultural water use efficiency depends on many complicated, interrelated factors. The farmer strives to optimize agricultural profits per unit of land and water without compromising the economic viability of California agriculture, water quality, or the environment. The success depends not only on availability of funds but also on technical feasibility and cost effectiveness, availability of technical assistance, and ability and willingness of growers, irrigation industry, and water district staff. Opportunities also exist through CALFED to implement efficiency measures other than cost-effective EWMPs that provide water quality and flow timing benefits for the local agency or to provide regional and/or statewide benefits.

Designing and installing efficient irrigation and water distribution systems will not necessarily result in improved efficiency if the system is not well managed. The management of water through the district distribution system and irrigation management on the farm are also important.

Reducing evaporation requires precise application of water. Shifting crops requires strategies to promote the practice. Stressing crops (regulated deficit irrigation) requires careful scheduling and application of water and may have additional costs and adverse impact on crop quality or soil salinity. All these actions call for incentive programs and policies. In the case of RDI, research is needed to evaluate the level of current practices, extend of implementation of these practices, and quantify RDI’s benefits and impacts.

Many growers and irrigation districts perceive that implementing efficiency measures could impact their water rights. This concern stems from the idea that conserved water may be used by others, causing a loss of rights to the conserved water. This perception is a factor that impedes implementation of conservation.

Measurement, Planning and Evaluation

The state lacks comprehensive data on the acreage under various methods of irrigation, applied water, crop water use, cultural requirements, irrigation efficiency, water use and net water savings, and the cost of irrigation improvements per unit of saved water. Lack of data is an obstacle for assessing irrigation efficiencies and planning further improvement. Collection and management and dissemination of such data to growers, districts, and state planners are necessary for promoting increased water use efficiency. A concern identified by the Advisory Committee members was a lack of statewide guidance to assist regions and districts to collect the data needed for future Water Plan Updates in a usable format.

Resources

The shift to pressurized irrigation systems requires additional energy resources such as electricity, gas, and diesel. They also require pipelines, pumps, filters and filtration systems, and chemicals for cleaning drip systems.

Education and Motivation

Improving agricultural water use efficiency depends on disseminating information on the use, costs, benefits, and impacts of technologies and on providing incentives for implementation. Existing evidence, although limited, indicates a strong response to financial incentives.

Dry-Year Considerations

In dry years, California's water supply is inadequate to meet its current level of use, and agriculture is often called upon to implement extraordinary water use efficiency or even land fallowing. Standard water use efficiency approaches to meet water needs during dry years need to be reviewed and other approaches need to be explored such as alfalfa summer dry-down in hot regions of the State with due consideration for third party impacts.

Recommendations to Achieve Additional Agricultural Water Use Efficiency

The following recommendations can help facilitate additional agricultural water use efficiency:

1. The state should identify and establish priorities for future grant programs and other incentives. Develop a process for quantification and verification of intended benefits of projects receiving state loans and grants.
2. The state should fund technical and planning assistance to improve water use efficiency including: local efforts to implement EWMPs and meet CALFED WUE goals. Provide support in the form of technical and financial assistance to the Agricultural Water Management Council to support its oversight for implementation, monitoring, and reporting of all cost-effective EWMPs. In cooperation with the agricultural community, fund research, development, demonstration, monitoring and evaluation projects that could improve agricultural water use efficiency. Support programs that encourage the development of new cost-effective water savings technologies and practices and evaluate cost-effectiveness of practices. Develop methodology for quantifying water savings and costs associated with hardware upgrades, water management, and evapotranspiration reduction projects proposed in this strategy.
3. The Agricultural Water Management Council should incorporate CALFED Quantifiable Objectives within the Agricultural Water Management Planning and Implementation process. More research should be directed towards determining benefits and impacts of reducing non-productive evaporation and reducing crop evapotranspiration. State's Loans & Grants process should provide ample opportunities for small districts and economically disadvantaged communities, tribes and community-based organizations to benefit from technical assistance, planning activities, and incentive programs, based on environmental justice policies.
4. Agricultural Water Management Council should encourage more water suppliers to join the Memorandum of Understanding and broaden its signatory base. AWMC should get the support of the state and local agencies for full implementation of Efficient Water Management Practices by signatories and encourage the addition of new EWMPs as benefits are identified.
5. Expand CIMIS, mobile laboratory services, and other training and education programs to improve distribution uniformity, irrigation scheduling and on-farm irrigation efficiency.
6. The state should fund large and long-term ET reduction (RDI) demonstration and research plots and other promising programs to reduce evapotranspiration..
7. Based on the long-term ET reduction studies and research, DWR should develop informational guidelines that define the crop water consumption reduction practices (RDI, mulch, alfalfa dry down,

etc.), identify how they can be implemented for each crop; their potential crop benefits and impacts, water savings, and estimate costs for growers and districts to implement.

8. Encourage billing by volume of water delivered rate structures, or other incentives that improve water use efficiency.
9. Collect, manage and disseminate statewide data on acreage under various irrigation methods, the amount of water applied, crop water use, and the benefits and costs of water use efficiency measures. Develop statewide guidance to assist regions and districts to collect the type of data needed, in a form usable for future Water Plan Updates. DWR work with the AWMC to develop a database of information from the Water Management Plans on water use-related data for dissemination and for Water Plan Update.
10. Develop community-based educational and motivational strategies for conservation activities to foster water use efficiency, with the participation of the agricultural and water industries and environmental interests. Develop partnership between state, federal, UC Cooperative Extension Service, farm advisors, irrigation specialists, state educational and research institutions to provide educational, informational, and training opportunities to growers, district staff and others on variety of water and irrigation management practices, operation, and maintenance.
11. The state should explore and identify innovative technologies and techniques to improve water use efficiency by developing new water efficiency measures to correspond with new information. Consider fast track pilot projects, demonstrations, and model programs exploring state-of-the-art water saving technologies and procedures and publicize results widely. Foster closer partnership among growers, water districts and irrigation industry and manufacturers who play an important role in research, development, manufacturing, distribution, and dissemination of new and innovative irrigation technologies and management practices.

Information Sources

- California Water Plans 93 and 98. Department of Water Resources
- Water Use Efficiency Program Plan. Programmatic EIS/EIR Technical Appendix. July 2000. CALFED Bay-Delta Program.
- Agricultural Water Use Efficiency Program. DWR. Office of WUE. http://wwwdwr.water.ca.gov/
- California Irrigation Management Information System (CIMIS). www.cimis.water.ca.gov
- California Department of Water Resources: Loans & Grants. http://wwdpla.water.ca.gov/supply/loans/loans.html
- California Agricultural Water Management Council: www.awmc.org
- California energy Commission. www.consumerenergycenter.com/
- California Farm Water Coalition. www.cfwc.com
- California Polytechnic State University, Irrigation Training and Research Center (ITRC). www.itrc.org/index.html
- California Urban Water Conservation Council. www.cuwcc.org
- Center for Irrigation Technology (CIT), California State University, Fresno. www.atinet.org/newcati/cit
- County Agricultural Commissioners.
- Association of California Water Agencies(ACWA). www.acwanet.com
- United States Bureau of Reclamation, Watershare Program. www.watershare.mp.usbr.gov
- United States Department of Agriculture/Agricultural Research Station. www.fsa.usda.gov.ca/ca.htm and www.pwa.ars.usda.gov/locations.shtml
- University of California Cooperative Extension. www.dnar.ucop.edu
- United States Geological Survey. www.usgs.gov
- USDA Natural Resources Conservation Services. www.nrcs.usda.gov
- Water Reuse Association. www.webcom.com/h2o

Conjunctive Management and Groundwater Storage

Conjunctive management is the coordinated operation of surface water storage and use, groundwater storage and use, and conveyance facilities. Although surface water and groundwater are sometimes considered to be separate resources, they are connected by the hydrologic cycle. Conjunctive management allows surface water and groundwater to be managed in an efficient manner by taking advantage of the ability of surface storage to capture and temporarily store storm water and the ability of aquifers to serve as long-term storage.

There are three primary components to a conjunctive management project. The first is to recharge groundwater when surface water is available to increase groundwater storage. In some areas this is accomplished by reducing groundwater use and substituting it with surface water, allowing natural recharge to increase groundwater storage (also called in-lieu recharge). The second component is to switch to groundwater use in dry years when surface water is scarce. The third component is to have an ongoing monitoring program to evaluate and allow water managers to respond to changes in groundwater, surface water, or environmental conditions that could violate management objectives or impact other water users. Together these components make up the conjunctive management project.

Groundwater Recharge

Groundwater recharge is the movement of surface water from the land surface, through the topsoil and subsurface, and into de-watered aquifer space. Recharge occurs naturally from precipitation falling on the land surface, from water stored in lakes, and from creeks and rivers carrying storm runoff. Recharge also occurs artificially from water placed into constructed recharge ponds (also called spreading basins), from water injected into the subsurface by wells, and from surface storage releases into creeks and rivers beyond what occurs from the natural hydrology (for example, by releases of imported water). Significant amounts of artificial recharge can also occur either intentionally or incidentally from applied irrigation water and from water placed into unlined conveyance facilities. Groundwater banking is the recharge (often of imported surface water or local flood water) into de-watered aquifer space for later recovery and use or exchange with others.

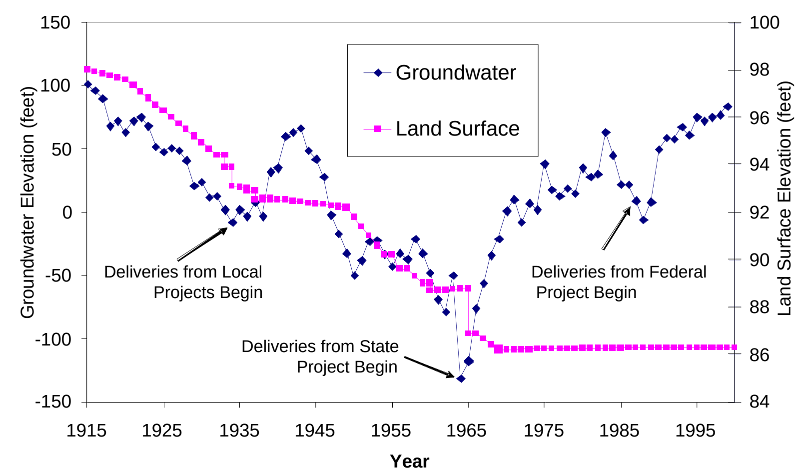
Other topics in the Water Plan that are related to conjunctive management include the strategies on Groundwater Remediation / Aquifer Remediation, Recharge Areas Protection, Water Transfers, and System Reoperation.

Current Conjunctive Management in California

Conjunctive management has been practiced in California to varying degrees since the Spanish mission era. The first known artificial recharge of groundwater in California occurred in southern California during the late 1800’s and is now used as a management tool in many areas. Two examples illustrate the types of conjunctive management underway on a regional and local scale. In Southern California, including Kern County, conjunctive management has increased average year water deliveries by over 2 million acre-feet (AGWA, 2000). Over a period of years, artificial recharge in these areas has increased the water currently in groundwater storage by approximately 7 million acre-feet.

Santa Clara Valley Water District releases local supplies and imported water into more than 20 local creeks for artificial instream recharge and into more than 70 recharge ponds to recharge a total of about 157 thousand acre-feet annually. Conjunctive management has virtually stopped land subsidence caused by heavy groundwater use and has allowed groundwater levels to recover to those of the early 1900s (see Figure 1).

Figure 1. Relationship between Groundwater Elevations and Land Subsidence in Santa Clara County

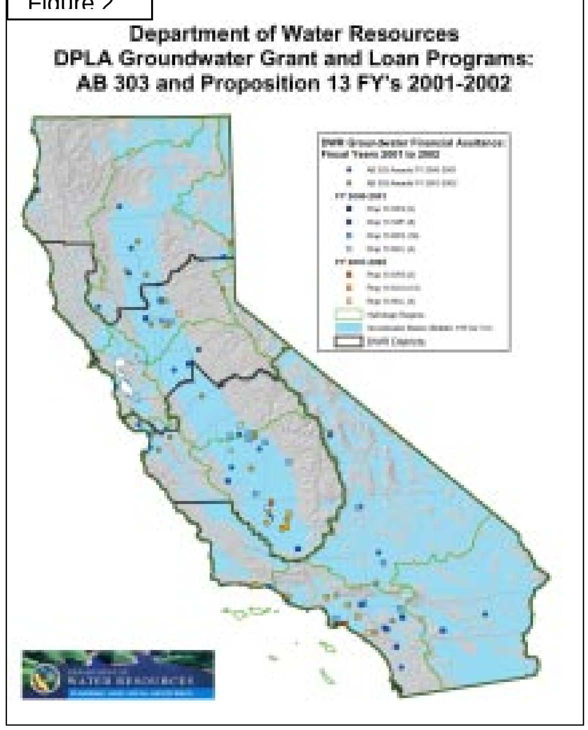


While comprehensive statewide data on the planning and implementation of conjunctive management at the local agency level is not available, DWR's Conjunctive Water Management Program provides an indication of the types and magnitude of projects that water agencies are currently pursuing. The program has awarded over $130 Million in grants and loans for project funding and study throughout California in fiscal years 2001 and 2002 (see Figure 2).

Potential Benefits from Conjunctive Management

Conjunctive management is implemented to improve water supply reliability, to reduce groundwater overdraft and land subsidence, to protect water quality, and to improve environmental conditions. Conservative estimates[1] of additional implementation of conjunctive management indicate the potential to increase average annual water deliveries throughout the state by 500 thousand acre-feet with about 9 million acre-feet of "new" groundwater storage. New storage includes both reoperation of existing groundwater storage and recharging water into currently de-watered aquifer space. More aggressive estimates from screening level studies indicate the potential to increase average annual water deliveries by 2 million acre-feet with about 20 million acre-feet of new storage.

Figure 2



The potential benefits from additional conjunctive

[1] Information in this section was derived from five sources: 1) Proposition 13 Groundwater Storage Applications to DWR for fiscal year 2001-2002, 2) A 2000 report by the Association of Groundwater Agencies entitled, "Groundwater and Surface Water in Southern California", 3) A 1998 report by the Natural Heritage Institute entitled, "Feasibility Study of a Maximal Program of Groundwater Banking", 4) A 2002 report by the Natural Heritage Institute entitled, "Estimating the Potential for In-Lieu Conjunctive Management in the Central Valley", 5) A 2002 report by the U.S. Army Corps of Engineers report entitled, "Conjunctive Use for Flood Protection". Methodology for obtaining these estimates is presented in Volume 4.

management are highly dependent on adequate water quality and the ability to capture, convey, and recharge surface water. The above estimates are based on increases in local water deliveries from individual projects with project specific sources of recharge supply and do not necessarily reflect a statewide increase in supply reliability. An increase in statewide supply reliability only occurs when the individual projects use water that would otherwise not be used by other water users or that is needed for regulatory requirements such as water quality, fish and wildlife, and navigation. The more aggressive estimates are based on assumptions that require major reoperation of existing surface water reservoirs and groundwater storage to achieve the benefits and do not fully consider the conveyance capacity constraints for exports from the Delta and other conveyance facilities. Expanding existing or developing new storage or conveyance infrastructure can increase the flexibility and ability to conduct conjunctive management projects. It is also possible to reoperate the existing system and to improve the underlying operational conditions to overcome these constraints.

In addition to water supply benefits, conjunctive management can provide environmental benefits when recharge basins are designed to be compatible with wildlife habitat, such as using natural floodplains and wetlands as recharge areas. Re-operation of surface water storage and use conjunctively with groundwater storage and use can avoid impacts to aquatic species by allowing better management of instream flow and water quality conditions.

Conjunctive Management Case Example Orange County Groundwater Replenishment System

The Groundwater Replenishment (GWR) System is a groundwater management and water supply project jointly sponsored by the Orange County Water District (OCWD) and Orange County Sanitation District (OCSD). The project will take highly treated urban wastewater and treat it to beyond drinking water standards using advanced membrane purification technology. The water will be used to expand an existing underground seawater intrusion barrier by injecting the water into the groundwater basin along the coast. Extraction wells located throughout the basin will draw potable water for municipal and industrial uses.

The GWR System will provide many benefits to Orange County and California.

- Supplements existing water supplies by providing a new, reliable, high-quality source of water to recharge the Orange County Groundwater Basin and protect the basin from further degradation due to seawater intrusion.
- Reduces the amount of treated wastewater released into the ocean and delays the need for another ocean outfall.
- Decreases reliance on imported water from northern California and the Colorado River.
- Helps drought-proof Orange County using a locally-controlled project.
- Reduces mineral build up in Orange County's groundwater by providing a new source of ultra-pure water to blend with other sources, including imported water.
- Uses about half the energy of imported water supplies.

Implementation of the GWR System will be phased. The current schedule calls for Phase 1 of the proposed project to produce up to 72,000 acre-feet per year (AF/yr) of recycled water for groundwater recharge to begin operation in 2007. The total cost of the project is estimated to be $453 Million. The unit cost of the supply is $516.00 per acre-foot.

Potential Costs of Conjunctive Management

Grant applications from DWR's fiscal year 2001-2002 Conjunctive Water Management Program show project costs ranging from $10 to $600 per acre-foot of increase in average annual delivery. The wide range of costs is due to many factors including project complexity, regional differences in construction costs, availability and quality of recharge supply, intended use of water, and treatment requirements. In general, urban uses can support higher project costs than agricultural uses. The average project cost of all applications received by DWR is $110 per acre-foot of increase in average annual delivery. This average unit cost translates to total implementation costs of approximately $1.3 billion for the more conservative level of implementation. While these cost estimates are specific to projects evaluated by DWR, they provide a good indication of implementation costs statewide. The cost of implementing the more aggressive level of conjunctive management is unknown.

Major Issues Facing Additional Conjunctive Management

The major issues facing conjunctive management are:

Lack of Data

There is rarely a complete regional network to monitor groundwater levels, water quality, land subsidence, or the interaction of groundwater with surface water and the environment. Data is needed to evaluate conditions and trends laterally over an area, vertically at different depths, and over time. Also, there is often a reluctance of individuals who own groundwater monitoring or supply wells to provide information or allow access to collect additional information. The result is that decisions must be made with only approximate knowledge of the "true" system. This uncertainty can make any change in operation of groundwater storage unpredictable and controversial.

Infrastructure and Operational Constraints

Physical capacities of existing storage and conveyance facilities are often not large enough to capture surface water when it is available in wet years. Operational constraints may also limit the ability to use the full physical capacity of facilities. For example, permitted export capacity and efforts to protect fisheries and water quality in the Delta often limit the ability to move water to groundwater banks south of the Delta.

Surface Water and Groundwater Management

In California, water management practices and the water rights system treat surface water and groundwater as two unconnected resources. In reality, there is often a high degree of hydrologic connection between the two. Under predevelopment conditions many streams received dry weather base flow from groundwater storage, and streams provided wet weather recharge to groundwater storage. Water quality and the environment can also be influenced by the interaction between surface water and groundwater. Failure to understand these connections can lead to unintended impacts. For example, studies by the University of California, Davis indicate that long term groundwater pumping in Sacramento County has reduced or eliminated dry season base flow in sections of the Cosumnes River with potential impacts to riparian habitat and anadromous fish.

In California, authority is separated among local, state and federal agencies for managing different aspects of groundwater and surface water resources. Several examples highlight this issue: 1) SWRCB regulates surface water rights dating from 1914, but not rights dating before 1914; 2) SWRCB also regulates groundwater quality, but not the rights to use groundwater; 3) County groundwater ordinances and local agency groundwater management plans often only apply to a portion of the groundwater basin, and those with overlapping boundaries of responsibility do not necessarily have consistent management objectives;4) Except in adjudicated basins, individuals have few restrictions on how much groundwater they can use, provided the water is put to beneficial use on the overlying property. Failure to integrate water management across jurisdictions makes it difficult to manage water for multiple benefits and provide for sustainable use including the ability to identify and protect or mitigate potential impacts to third parties, ensure protection of legal rights of water users, establish rights to use vacant aquifer space and banked water, protect the environment, recognize and protect groundwater recharge and discharge areas, and protect public trust resources. The Protecting Recharge Areas and Urban Runoff Management strategies describe how land use planning can affect groundwater recharge.

Water Quality

Groundwater quality can be degraded by naturally occurring or human introduced chemical constituents, low quality recharge water, or chemical reactions caused by mixing water of differing qualities. Protection of human health, the environment, and groundwater quality are all concerns for programs that recharge urban runoff or reclaimed/ recycled water. The intended end use of the water can also influence the implementation of conjunctive management projects. For example, agriculture can generally use water of lower quality than needed for urban use, but certain crops can be sensitive to some constituents like boron. New and changing water quality standards and emerging contaminants add uncertainty to implementing conjunctive management projects. In some cases, conjunctive management activities may need to be coordinated with groundwater clean up activities to achieve multiple benefits to both water supply and water quality.

Environmental Concerns

Environmental concerns related to conjunctive management projects include potential impacts on habitat, water quality, and wildlife caused by shifting or increasing patterns of groundwater and surface water use. For example, floodwaters are typically considered “available” for recharge. However, flood flows serve an important function in the ecosystem. Removing or reducing these peak flows can negatively impact the ecosystem. A key challenge is to balance the instream flow and other environmental needs with the water supply aspects of conjunctive management projects. There may also be impacts from construction and operation of groundwater recharge basins and new conveyance facilities.

Funding

There is generally limited funding to develop the infrastructure and monitoring capability for conjunctive management projects. This includes funding to develop and implement groundwater management plans, to study and construct conjunctive management projects, and to track, both statewide and regionally, changes in groundwater levels, groundwater flows, groundwater quality (including the location/spreading of contaminant plumes), land subsidence, changes in surface water flow, surface water quality, and the interaction and interrelated nature of surface water and groundwater.

Recommendations to Help Promote Additional Conjunctive Management

The following recommendations are for the state to facilitate conjunctive management:

1. Encourage the development of regional groundwater management plans. Local water management agencies should coordinate with other agencies that are involved in activities that might affect long term sustainability of water supply and water quality within the basin or adjacent to the basin. Such

regional coordination will take different forms in each area because of dissimilar political, legal, institutional, technical, and economic constraints and opportunities. Regional groundwater management plans should be developed with assistance from an advisory committee of stakeholders to help guide the development, educational outreach, and implementation of the plans.

2. Continue funding for local groundwater monitoring and management activities and feasibility studies that enhance the coordinated use of groundwater and surface water. Additional monitoring and analysis is needed to track, both statewide and regionally, changes in groundwater levels, groundwater flows, groundwater quality (including the location/spreading of contaminant plumes), land subsidence, changes in surface water flow, surface water quality, and the interaction and interrelated nature of surface water and groundwater. There is a need to develop comprehensive data on existing, proposed, and potential conjunctive management projects throughout the state and identify and evaluate regional and statewide implementation constraints including availability of water to recharge, ability to convey water from source to destination, water quality issues, environmental issues, and costs and benefits.
3. Give priority for funding and technical assistance to conjunctive management projects that are conducted in accordance with a groundwater management plan, increase water supplies, and have other benefits including the sustainable use of groundwater, maintaining or improving water quality, and enhancing the environment. In addition, allow funding for projects that make use of wet season / dry season supply variability, not just wet year/dry year variability.
4. Assess groundwater management throughout the state to provide an understanding of how local agencies are implementing actions to use and protect groundwater, an understanding of which actions are working at the local level and which are not working, and how state programs can be improved to help agencies prepare effective groundwater management plans.
5. Improve coordination and cooperation among local, state, and federal agencies with differing responsibilities for groundwater and surface water management and monitoring to facilitate conjunctive management, to ensure efficient use of resources, to provide timely regulatory approvals, to prevent conflicting rules or guidelines, and to promote easy access to information by the public.
6. Encourage local groundwater management authorities to manage the use of vacant aquifer space for artificial recharge and to develop multi-benefit projects that generate source water for groundwater storage by capturing water that would otherwise not be used by other water users or the environment. For example, through reservoir reoperation, water recycling and reuse, and water conservation.
7. Work with wildlife agencies to streamline the environmental permitting process for the development of conjunctive management facilities, like recharge basins, when they are designed with pre-defined benefits or mitigation to wildlife and wildlife habitat.

Information Sources

- Association of Groundwater Agencies (AGWA). "Groundwater and Surface Water in Southern California." October 2000.
- CALFED. Common Assumptions, Conjunctive Use Inventory. In progress.
- CALFED. "Conjunctive Use Site Assessment – Draft Report". December 23, 1999
- *Fleckenstein, J.H., Anderson, M, Fogg, G.E. & Mount, J.* (2003), Managing Surface water-groundwater to restore fall flows in the Cosumnes River, Journal of Water Resources Management and Planning, in press.
- Natural Heritage Institute. "Designing Successful Groundwater Banking Programs in the Central Valley". 2000.
- Natural Heritage Institute. "Estimating the Potential for In-Lieu Conjunctive Water Management in the Central Valley". February 2002.
- Natural Heritage Institute. "The Hydrogeological Suitability of Potential Groundwater Banking Sites in the Central Valley". September 2001.
- Natural Heritage Institute. "Feasibility Study of Maximal Program of Groundwater Banking." December 1998.
- SWRCB. "Water Transfer Issues in California: Final Report to the California State Water Resources Control Board by the Water Transfer Workgroup". June 2002.
- U.S. Army Corps of Engineers. Conjunctive Use for Flood Protection. January 2002.

Conveyance

Conveyance provides for the movement of water. Specific objectives of natural and managed water conveyance activities include flood management, consumptive and non-consumptive environmental uses, and urban and agricultural water deliveries. Conveyance infrastructure includes natural watercourses as well as constructed facilities like canals, pipelines and related structures, including pumping plants, diversions, distribution systems and fish screens. Groundwater aquifers are also used to convey water. Conveyance ranges from the small local end-user distribution systems to the large watercourses that deliver water to, or drain, areas as large as multiple hydrologic regions.

Some considerations for balancing regional self-sufficiency with imports include:

- Technical feasibility of available regional options,
- Costs (capital, O&M, mitigation, financing, etc),
- Environmental impacts of regional options Vs. import projects
- The type of water management benefits produced (e.g. supply augmentation, water quality improvements, etc).

It is important to note that common water management objectives and option evaluation criteria do not consistently show favor toward either regional or inter-regional options. Determinations must be made at the project-level.

Current Conveyance in California

Every water project in California uses some type of conveyance to move water from the source to where it is needed. An extensive system of conveyance facilities moves water with the use of its natural and constructed waterways. At the local level, water is distributed from locally developed sources to the end users. Since the state's ecosystem depends on water flow and quality in creeks, streams and rivers, an overall objective is to balance the operation and maintenance of these conveyances to meet the needs of all sectors.

The two largest conveyance projects in California are the State Water Project (SWP) and the Central Valley Project (CVP). Both the SWP and the CVP use natural rivers and constructed conveyances to deliver water from storage reservoirs in northern California to a broad array of agricultural water agencies in northern California and the San Joaquin Valley, as well as urban water agencies in the Sacramento Valley, San Francisco Bay Area, central coast, and urban Southern California.

A number of other inter-regional conveyances have been developed by local agencies. For example, East Bay Municipal Utility District and the San Francisco Public Utilities Commission have developed major conveyance systems that transport water from Sierra Nevada rivers directly to their service areas. The Los Angeles Department of Water and Power developed the Los Angeles Aqueduct to convey water from the Owens Valley to Los Angeles. A major source of water in Southern California continues to be diversion and distribution of Colorado River water via the All American Canal serving the Imperial Irrigation District, the Coachella Canal serving the Coachella Valley and the Colorado River Aqueduct delivering water to urban Southern California. Each of these conveyance systems is a major contributor to each region's water supplies and overall water supply reliability.

The existing networks of inter-regional conveyance systems would not be capable of producing benefits if not for the ability of local water agencies to use conveyance to distribute imported, or locally produced, water to the end users, such as treated drinking water to residential or industrial users or irrigation water to agricultural users. In fact, conveyance is necessary in order for benefits to occur with virtually every other facet of local water management, such as desalination, recycling, use efficiency, storage projects.

Other conveyance activities include environmental and recreation-related conveyance activities that can either be intentional or incidental to agricultural and urban water management activities. This could involve beneficiaries such as fish habitat (temperature, flow or quality improvements), riparian vegetation, rafting or recreational turf.

One current planning process that seeks to enhance conveyance connectivity at the regional level is the CALFED Bay Area Water Quality and Supply Reliability Program. This program is examining conveyance projects as well as other water management tools such as storage, recycling, and desalination in the Bay Area region to improve the area's drinking water quality and supply reliability. Existing regional, multi-agency conveyance projects in the Bay Area already include the, Hetch Hetchy Aqueduct, South Bay Aqueduct and emergency interconnects between various agencies. The program examines the effectiveness of additional regional conveyance projects that maximize operational efficiency and flexibility[1]. Examples include expansion of

CALFED Conveyance

Under the CALFED Conveyance Program, the CALFED Record of Decision calls out specific through-Delta conveyance actions that are to be either directly implemented or otherwise pursued including:

- Increase SWP permitted pumping to 8,500 cubic feet per second and install permanent, operable barriers in the south Delta
- Increase SWP permitted pumping to 10,300 cfs and construct Clifton Court Forebay fish screens
- Construct Tracy Fish Test Facility
- Implement Lower San Joaquin River Floodways Improvements and Ecosystem Restoration Project
- Old River and Rock Slough Water Quality Improvement Projects
- Evaluate improved operational procedures for the Delta Cross Channel and simultaneously evaluate a screened through-Delta facility on the Sacramento River up to 4,000 cfs
- Implement North Delta Flood Control and Ecosystem Restoration Improvements Program
- Consider the need for conveyance interties between the SWP and CVP in the vicinity of Delta Mendota Canal Mile Post 7 and between Clifton Court Forebay and the Tracy Pumping Plant
- Continue the Temporary Barriers Project until permanent flow control structures are built
- Evaluate a bypass to the San Felipe Unit at the San Luis Reservoir to reduce risk from the low point water levels in the San Luis Reservoir
- Facilitate water quality exchanges and similar programs to make high quality Sierra Nevada water available to urban Southern California interests
- Assist in implementation of the Sacramento and San Joaquin Comprehensive Study to improve flood control and ecosystem restoration

[1] System flexibility is defined as the ability to adaptively operate, or optimize, multiple water management options by controlling the timing, flow rate, location or quality of available supplies.

the South Bay Aqueduct and additional raw- and treated-water interconnects between adjacent service areas.

Another example of the use of conveyance to provide system flexibility within a region is the Metropolitan Water District of Southern California's network of local conveyance facilities. In addition to numerous locally developed water management options, this region receives water from multiple importation projects – namely the SWP and Colorado River. Both the importation and local options operate with different and often dynamic complexities involving water quality, hydrologic variability, costs, timing, risk levels, geographical distribution and capacities. Therefore, significant water management benefits occur by integrating water operations (using conveyance facilities) to help optimize operations based on the complexities described above.

Benefits of Conveyance

The main benefits of conveyance to the urban, agricultural and environmental water use sectors are in maintaining or increasing water supply reliability, augmenting current water supplies, and providing water system operational flexibility. For the environmental sector, benefits include in-stream flows, appropriate temperatures and water quality for aquatic and riparian habitat. It is important to recognize that improving water supply reliability through system flexibility is just as valuable as increasing overall supply. Indeed, conveyance capacity improvements can enhance reliability without augmenting supplies or reducing demand by increasing system operational flexibility. Other specific benefits are:

- Conveyance is necessary for many of the other resource management strategies. Conveyance is needed to move water in water transfers between sellers and buyers. In order for water to be developed by new groundwater or surface storage, diversion facilities must be capable of filling the storage. Also, facilities must then be in place to convey the storage releases to the users at the right times and flow rates.
- Conveyance improvements can provide the flexibility to divert and move water at times that are less harmful to fisheries.
- Conveyance can improve water quality by moving more water when water quality conditions are better or less impacted by the movement of water.
- Given the high-intensity, short duration characteristics of California's hydrology, improved conveyance capacities can divert more water during high flow/less competitive periods, and consequently reduce the pressure to divert water during low flow/highly competitive periods.
- Other benefits of conveyance improvements generally include:
    - Enhancement of flood control capability
    - Increases in water use efficiency
    - Increases in resiliency to catastrophic events
    - Reductions in operating costs
    - Improvements to instream and riparian habitat

Potential Costs of Water Conveyance

Conveyance costs can be a significant portion of the costs in a water management system. The cost of water conveyance heavily depends on the local circumstances, how far and when the water needs to be conveyed and topography (e.g. pumping Vs gravity flow). For example, it costs less to convey water from Oroville Dam to Yuba City in Northern California, all gravity flow, than to convey water from Oroville Dam to the South Coast Hydrologic Region. Conveying water through the Delta and over the Tehachapi

Mountains increases water costs. CALFED estimates of Delta conveyance improvements may cost about $1 billion to construct. However, until all alternatives for these facilities are fully evaluated, this cost is tentative. The state's investment in lining All American and Coachella Canals is estimated at $235 million.

Major Issues Facing Conveyance

The major issues facing conveyance are:

Maintenance

It is essential at a minimum to maintain the current level of conveyance capacity for both natural and constructed facilities. This is likely to take on greater importance over time due to aging water infrastructure, the increasingly higher costs of maintenance, and the increasing demands with increasing population. While concerns are likely to focus on adequate financial resources to maintain conveyance infrastructure, there is the special case of diminishing conveyance capacity in natural watercourses. This is most critical from both a water conveyance and flood passage standpoint in the channels of the Delta.

Science

Water managers, planners and biologists continue to struggle to identify and understand the relationships between hydrodynamics, flow timing, fish timing and movement, water temperature, geomorphology, water quality, environmental responses, global climate change and other conveyance related considerations so they can optimally plan, develop, operate and maintain natural and constructed conveyance infrastructure.

Regulatory Compliance

New conveyance projects may need to address impacts under the application of various laws, regulatory processes and statutes such as Public Trust Doctrine, Area of Origin statutes, CEQA, NEPA, the Clean Water Act and the Endangered Species Acts.

Local and Regional Water Supply Reliability

Greater interconnections are needed to help improve water supply reliability, as evidenced by how California has responded during drought conditions. Each water system has its own level of water supply reliability, based largely on storage and conveyance systems, hydrology, and level of demand. Operational flexibility, particularly during emergency conditions is a primary benefit of greater interconnection of independent water systems include.

CALFED Through-Delta Strategy

The CALFED objective for the Conveyance Program employs a through-Delta approach to conveyance. Delta conveyance capacity and operational restrictions have been identified as key bottlenecks to improving the water supply reliability for in-Delta and water export users. The current lack of flexibility also limits the ability to take advantage of other water management strategies such as water transfers, including transfer of previously stored water, conjunctive management, groundwater storage, and north of Delta water use efficiency. A key challenge for the California Bay-Delta Authority is to implement a strategy that will provide the necessary flexibility to the system and be protective of water quality, Bay-Delta hydrodynamics, fisheries, and habitat.

Area of Origin Interest

Inter-regional movement of water is sometimes opposed by the source water counties. In addition to struggling to augment local water supplies to meet growing demands, area of origin interests often feel that the downstream water users could or should be more committed to managing the natural infrastructure, such as watersheds, from which their imported water originates.

Recommendations

The following recommendations apply to state, federal and local water agencies:

1. Consider and implement feasible conveyance system operational changes.
2. Assure adequate resources to maintain existing conveyance facilities and capacity. This may include development of a strategy to maintain channel capacity in areas of the Delta.
3. Promote development of more extensive interconnections among water resources systems such as, and in addition to, the SWP-CVP intertie or improved connectivity within the Bay Area Region. It is likely that leadership and funding on this will be at the local level.
4. Financially support the CALFED through-Delta conveyance improvements per CALFED ROD.
5. Provide finances for lining of AAC & Coachella Canals – to make available 102 taf annually to South Coast Region MDWSC agency.

Information Source

- CALFED Record of Decision and Conveyance Program http://calfed.ca.gov.

Desalination

Desalination is a water treatment process for the removal of salt from water for beneficial use. Desalination is used on brackish (low-salinity) water as well as seawater. In California, the principal method for desalination is reverse osmosis. This process can be used to remove salt as well as specific contaminants in water such as Trihalomethane precursors, volatile organic carbons, nitrates and pathogens.

Only desalination for municipal purposes, that is, desalination used by public and private water agencies is considered in the following discussion. Desalination by industrial and commercial entities is not considered since those applications of desalting generally involve treating fresh water to a higher standard to meet a specific need. Desalination plant capacity for this paper is expressed in terms of the fresh or potable water capacity of the plant. Total water costs are given in $ per acre-foot of fresh of potable water produced.

Current Desalination in California

Desalination began in California in 1965. The rapid rise in installed capacity over the last decade has occurred mostly due to dramatic improvements in membrane technology and the increasing cost of conventional water supply development. In 1999 there were 30 desalting plants operating in California for municipal purposes with a total capacity of about 80,000 acre-feet per year.

Assembly Bill 2717 (Hertzberg, Chapter 957, Statutes of 2002) called for DWR to establish a Desalination Task Force to look into:

- Potential opportunities for desalination of seawater and brackish water in California
- Impediments to using desalination technology
- What role, if any, the state should play in furthering the use of desalination

The Task Force completed its mission in October 2003 after six month of deliberations. DWR prepared recommendations (see text box on the following pages) with significant input from Task Force members, comprised of representatives from twenty-seven organizations.

In November, 2001, Metropolitan Water District of Southern California (MWD) issued a Request for Proposal (RFP) under its new Seawater Desalination Program targeting 50,000 acre-feet –per-year (AF/Y) of sustained production. Through a competitive process, selected projects would be eligible for financial assistance up to $250/AF. San Diego County Water Authority is also investigating seawater desalting facilities in addition to the 50 mgd Carlsbad plant proposed under the MWD program described above. A number of San Francisco Bay area agencies are jointly funding planning studies for desalination, as are several central coastal agencies.

Desalination Recommendations Summary (2003)

General Recommendations:

1. Since each desalination project is unique and depends on project-specific conditions and considerations, each project should be evaluated on a case-by-case basis.
2. Include desalination, where economically and environmentally appropriate, as an element of a balanced water supply portfolio, which also includes conservation and water recycling to the maximum extent practicable.
3. Ensure equitable access to benefits from desalination projects and ensure desalination projects will not have disproportionate impacts particularly to low-income and/or ethnic communities.
4. The state should create mechanisms that allow the environmental benefits associated with transitioning dependence on existing water sources to desalinated water to be realized.
5. In conjunction with local governments, assess the availability of land and facilities for environmentally and economically acceptable seawater desalination.
6. Results from monitoring at desalination projects should be reported widely for the broadest public benefits. Encourage opportunities to share information on operational data. Create a database and repository for storing and disseminating information.
7. Create an Office of Desalination within the Department of Water Resources to advance the state’s role in desalination.

Energy and Environment Related Recommendations:

8. Ensure seawater desalination projects are designed and operated to avoid, reduce or minimize impingement, entrainment, brine discharge and other environmental impacts. Regulators, in consultation with the public, should seek coordinated mechanisms to mitigate unavoidable environmental impacts.
9. Identify ways to improve water quality by mixing desalinated water with other water supplies.
10. Where feasible and appropriate, utilize wastewater outfalls for blending/discharging desalination brine/concentrate.
11. Compare reasonable estimates of benefits, costs and environmental impacts for desalination with those for other water supply alternatives realistically available to that area.
12. Recognizing the importance of power costs to the costs of desalination, consider strategies that will allow project sponsors to access non-retail power rates.
13. Clarify the applicability of non-retail energy pricing for desalination facilities.
14. Study the energy intensity and rates currently paid for energy used to provide water from various sources including desalination.
15. Study the potential for developing renewable energy systems in California, in conjunction with desalination implementation strategies.
16. Identify ways that desalination can be used in a manner that enhances, or protects the environment, public access, public health, view sheds, fish and wildlife habitat and recreation/tourism.

Planning and Permitting Related Recommendations:

17. To improve communication, cooperation, and consistency in permitting processes, encourage review processes for each desalination project to be coordinated among regulators and the public.
18. Evaluate all new water supply strategies including desalination based upon adopted community General Plans, Urban Water Management Plans, Local Coastal Plans, and other approved plans that integrate regional planning, growth and water supply/demand projections. Environmental reviews should ensure that growth related impacts of desalination projects are properly evaluated.

19. Ensure adequate public involvement beginning early in the conception and development of desalination projects and continuing throughout planning, design and evaluation processes. Coordinate public notification, outreach and public involvement strategies.
20. If multiple desalination projects are proposed within a region, coordinate development and analysis of these projects, including their benefits and cumulative impacts.
21. For proposed desalination facilities co-locating with power plants, analyze the impacts of the desalination facility operations apart from the operations of the co-located facilities. This will identify the impacts of the desalination facility operations when there are reductions in cooling water quantities. This recommendation is not intended to dictate California Environmental Quality Act alternatives that must be evaluated.
22. When desalination projects propose environmental benefits, identify the assurances that those benefits will be realized.
23. Evaluate the effects of desalinated water on existing water supply distribution systems.
24. Each community should consider the appropriate role, if any, for private companies in a desalination project or proposal.
25. Private desalination projects, and private developers and plant operators, should be required to fully disclose the same information as a publicly owned and operated facility.
26. To avoid potential international trade agreement violations, no legal standard or regulation should discriminate against an applicant based on ties to multi-national corporations.
27. Investigate the ramifications of designating ocean and estuarine waters in proximity to desalination intakes as drinking water beneficial use.

Funding Related Recommendations:

28. Provide funding for research and development projects (e.g., feedwater pretreatment, the value and limitations of beach wells for feedwater intake, other technologies to reduce entrainment and impingement impacts, strategies for brine/concentrate management, opportunities for energy efficiencies and application of alternative energy sources and combined energy and desalination technologies).
29. In addition to other eligibility criteria, state funding should give high priority to those desalination projects that provide the greatest public benefits, such as: 1) serve areas implementing all conservation and recycling programs to the maximum extent practicable; 2) demonstrate long-term environmental benefits; 3) avoid or reduce environmental impacts to the extent possible; 4) reduce health risks by improving water quality; and 5) ensure equitable access to benefits from desalination projects and include feasible mitigation for any environmental justice impacts.

Potential Benefits of Municipal Desalination in California

The benefits that desalination can provide are:

- Increase in water supply
- Reclamation and beneficial use of waters of impaired quality
- Increased water supply reliability during drought periods
- Diversification of water supply sources
- Improved water quality
- Protection of public health

The primary benefit of desalting is to increase California's water supply. Seawater desalting creates a new water supply by tapping the significant supply of feedwater from the Pacific Ocean.

The following table shows the number and capacity of seawater desalting plants in operation and in design and construction as of 2002 and plants that are currently planned or projected for construction. These include the plants proposed in response to the MWD solicitation and plants in Huntington Beach, the Monterey Bay area and Marin County. While not all of these are likely to be constructed this decade, it is assumed that they, or an equivalent number, will be operational by 2030.

Desalting in California for New Water Supply

	Plants in Operation		Plants in Design and Construction		Plants Planned or Projected	
Feedwater Source	Number of Plants	Annual Capacity	Number of Plants	Annual Capacity	Number of Plants	Annual Capacity
Groundwater	14	46,200	5	31,100	8	56,300
Seawater	4	1,150	1	250	9	187,100
Total	18	47,350	6	31,350	17	243,400
Cumulative			24	78,700	31	322,100

1. Capacity in Acre-feet per year
2. Design and Construction – Construction underway or preparation of plans and specifications has begun
3. Planned – Planning studies underway
4. Projected – Assumed new or expanded capacity
5. Sources: "Water Desalination Report', and Worldwide Desalting Plants Inventory series by International Desalination Association.

In addition to the above, there is additional new water supply possible from desalting oil field production water in the San Joaquin and Salinas Valleys and brackish agricultural drainage water in the San Joaquin and Imperial Valleys. These are not quantifiable at present.

Desalting wastewater increases the range of beneficial uses for which recycled municipal wastewater can be used. Of the 1,200,000 AF/Y (see the Recycled Municipal Water strategy) in reclaimed water projected for 2030, approximately 150,000 AF/Y will include desalting in the treatment process.

Desalting groundwater allows groundwater of impaired quality to be adequately treated for potable use. Approximately 130,000 AF/Y in capacity is currently planned or projected to be constructed. Groundwater desalting may or may not be a "new" water supply depending upon the water portfolio or balance in the area or region where it occurs. It is, however, providing water from a source that is not currently being used for beneficial purposes.

Potential Costs of Desalination

Recent technological advances in various desalination processes have significantly reduced the cost of desalinated water to levels that are comparable, and in some instances competitive, with other alternatives for acquiring new water supplies. Desalination technologies are becoming more efficient, less energy demanding and less expensive. Significant progress and innovation in membrane technologies such as reverse osmosis (RO) has helped reduce costs. The RO process has been proven to produce high quality drinking water throughout the world for decades.

The estimated capital cost of 187,100 (see table on previous page) acre-feet per year in increased seawater desalting capacity is about $1 billion. The table below shows the range in total unit water cost that can be expected from plants desalting groundwater (or brackish), wastewater and seawater. These costs are based on the expected lifetime of the plant (20-30 years).

Desalting Total Water Costs

Type of Desalting Plant	Total Water Cost - $ per Acre-Foot
Groundwater	$250-500
Wastewater	$500-2000
Seawater	$800-2000

Major Issues Facing Desalination

Historically, the cost of desalting has been the major issue regarding desalting, with energy use a close second. As desalting costs have declined and the cost of traditional water supplies has increased, desalting is increasingly being considered. As a result, two additional issues have increased importance, environmental impacts and permitting (particularly for coastal plants).

Cost and Affordability

Desalination has historically been prohibitively expensive. The improvements in technology and the rising cost of conventional water supplies has made desalination competitive with importing water and recycled municipal wastewater in a number of cases. Cost is still an issue to consumers. The cost will be influenced by the type of feedwater, the available concentrate disposal options, the proximity to distribution systems, and the availability and cost of power. In some cases, the higher costs of desalting may be offset by the benefits of increased water supply reliability and/or the environmental benefits from substituting desalination for a water supply with higher environmental costs (e.g. Carmel River, Monterey Bay area).

Environmental Impact and Permitting

Brackish water desalination plants have fairly routine environmental and permitting requirements. Coastal desalination plants face much closer scrutiny. Locations within the coastal zone, and with the need for water intakes and outfalls, are subject to many reviewing agencies, organizations, and permitting requirements.

Seawater Intakes

Existing seawater intakes for power plant cooling are proposed as the source of supply for almost all of the currently proposed plants. In general, these existing intake systems have been shown to have fairly significant impacts on the coastal zone. Changes in power plant cooling technology may limit the potential capacity of seawater desalting on the coast. A number of coastal power plants that use once-through cooling from the ocean, may cease operation or convert to a “dry” cooling system. In addition, some power plants are not in continuous operation.

Concentrate Discharge

Desalination plants of any type produce a salt concentrate that must be discharged. The quantity and salinity of that discharge varies with the type of desalting plant and its operation. Brackish water plants in California discharge their concentrate to municipal wastewater treatment systems where they are treated and blended with effluent prior to discharge. Inland desalting plants without a discharge to the ocean may be limited by the type of discharge options available. Seawater desalination produces a concentrate approximately twice as salty as seawater. In addition, residuals of other treatment chemicals may also be in the concentrate. The seawater plants currently being planned will use existing power plant outfall systems to take advantage of dilution and mixing prior to discharge. The availability of power plant cooling systems to dilute the concentrate prior to discharge to the ocean will also be affected by the future of coastal power plants as discussed in the prior issue.

Energy Use

Desalination's primary operation cost is for power. A 50 mgd seawater plant (approximately 50,000 acre-feet per year assuming operating 90% of the time) would require about 33 MW of power. Forecasted seawater desalination of about 187,000 acre-feet per year would require about 123 MW of power. The reduction in unit energy use has been among the most dramatic improvements in recent years due to improvement in energy recovery systems.

Growth-Inducing Impacts

The availability of water has been a substantial limitation on development in a number of locations, primarily coastal communities. Since desalination on the coast is now a much more affordable option in comparison to the past, the availability of desalinated water could reduce this limitation.

Recommendations to Promote Desalination in California

1. DWR should lead the development of a consensus process, involving appropriate stakeholders, to identify criteria and prioritize the implementation of Task Force recommendations, given the expected expenditures, using existing and new funding sources (see above sidebar on Task Force recommendations).

Information Sources

- Water Desalination Task Force (AB 2717 [Hertzberg, Chapter 957, Statues of 2002])
- "Water Desalination - Findings and Recommendations", Department of Water Resources, October 2003
- Draft Desalination Issues Assessment Report, Center for Collaborative Policy, California State University, May 2003
- "Desalting in California", Division of Planning & Local Assistance, San Joaquin District (in preparation)
- "Seawater Desalination in California", California Coastal Commission (Draft Report for public review)
- "Seawater Desalination: Opportunities and Challenges", National Water Research Institute, March 2003.
- "Tapping the World's Largest Reservoir: Desalination", Western Water, January/February 2003

Drinking Water Treatment and Distribution

Drinking-water treatment includes physical, biological, and chemical processes to make water suitable for potable use. Distribution includes the storage, pumping, and pipe systems to protect and deliver the water to the customers. Even after preventing pollution and matching water quality to use (see preventing pollution and matching water quality to use strategies), drinking water supplies will generally still require some of level of treatment to achieve a potable level of quality, which will then need to be maintained in a distribution system. Widespread treatment of drinking water, especially disinfection and fluoridation, was one of the great public health advancements of the 20th century.

Current Status of Drinking Water Treatment and Distribution in California

The state of California has a role in ensuring the safety of the public water supply and the health of Californians who use it. Pursuant to State Department of Health Services regulations, all surface waters in California must be filtered and disinfected, except for a small number, like San Francisco's Hetch Hetchy water supply, that meet DHS's "filtration avoidance" criteria.[1] In general, basic surface water treatment consists of pretreatment (primarily sedimentation), filtration through sand and gravel followed by disinfection with chlorine. Many water suppliers have already implemented more advanced treatment to improve water quality using processes such as granular activated carbon (GAC) for filtration and ozone and chloramination (a combination of chlorine and ammonia) for disinfection.

In southern California, the Los Angeles Department of Water and Power has disinfected Owens Valley water with ozone for the past 20 years. The Metropolitan Water District is upgrading to ozone disinfection at its five treatment plants, which use either Delta water exclusively, or a blend of Colorado River and Delta water. UV radiation is a promising advanced disinfection technology, but has yet to be implemented in a large-scale domestic water treatment plant in California. The integration of multiple disinfectants also shows promise in optimizing protection from microbiological contaminants in drinking water. Some smaller water treatment plants use membrane filtration, which produces relatively high quality water. The waterworks industry is exploring the feasibility of point-of-entry (POE) and point-of-use (POU) devices, which would treat only that water used for domestic purposes, and which could provide relatively quicker and more cost-effective water quality improvements. Water systems that rely upon groundwater generally only disinfect well water with chlorine, unless a specific contaminant is affecting the water's intended use.

Distribution system water quality is emerging as an important issue in the waterworks community, especially given recent heightened awareness of water supply security. Historically, treated water storage and associated distribution systems were designed to meet fire suppression flow requirements rather than maintain system water quality. Threats to water quality in distribution systems include the introduction of contamination from cross-connections with non-potable water sources (such as recycled water), open treated water distribution reservoirs, and water main repair and replacement, as well as lead, the by-products of corrosion, and regrowth of microorganisms. Ironically, the implementation of ozone for disinfection, while effective in killing microbes, reducing objectionable tastes and odors, and generally forming fewer disinfection byproducts, can create conditions that can encourage the growth of

[1] Please refer to Volume 1, Chapter 2, for the legal and regulatory framework for drinking water treatment and distribution.

microorganisms in water distribution systems. Aging water system infrastructure--some well over 100 years old--in general is not being replaced or rehabilitated within the useful life of such facilities.
Small, rural water systems (i.e. those serving fewer than 3,300 service connections) face unique treatment and distribution challenges, primarily due to the lack of technical and financial capacity to adequately address water contamination. Such systems are often the most frequent violators of drinking water standards, and often must cope with some of the most difficult water quality constituents, such as arsenic, as well as more traditional but no less problematic contaminants such as nitrate and coliform bacteria.

Potential Benefits

Improved water quality can directly improve the health of Californians, thereby improving the state's standard of living and reducing the burden and costs on the state's healthcare system. Many water contaminants potentially cause cancer, nervous system and organ damage, developmental impairments, and dysfunction of the reproductive and endocrine systems; others can cause short-term gastrointestinal illnesses, resulting in lost work and school days. If poor water quality causes a need for medical treatment by many uninsured Californians, the costs will be borne by state health programs, such as MediCal, which directly impacts the state budget. In addition, many consumers who choose to purchase relatively expensive bottled water or home treatment units, could save more of their personal budgets if they instead used safe tap water.

The U.S. Environmental Protection Agency has proposed new regulations to reduce both the gastrointestinal and carcinogenic disease risks of drinking water. The agency estimates that the Long Term 2 Enhanced Surface Water Treatment Rule will prevent more than 1 million cases of cryptosporidiosis (a gastrointestinal ailment) and up to 140 premature deaths annually, providing $1.4 billion in benefits. EPA also estimates that the Stage 2 Disinfection Byproducts Rule will prevent up to 182 cases of bladder cancer per year, providing nearly $1 billion in benefits. The combined costs of these two proposed regulations are less than $24 per year for most households.

Potential Costs

Advanced water treatment itself is a relatively low percentage (on the order of one percent) of a customer's overall water bill. For example, the 40 million gallon-per-day North Bay Regional Water Treatment Plant, which serves Fairfield and Vacaville, treats a blend of Lake Berryessa and Delta water with GAC filtration and ozone. The operations and maintenance expenses of these processes cost $0.04 per 1,000 gallons, on a total metered charge of $3 per 1,000 gallons. As another example, the Metropolitan Water District of Southern California estimates that its capital upgrade to ozonation will cost about $83,000 per acre-foot per day of capacity, with operations and maintenance costs of $9-$12 per acre-foot (equal to $0.03 to $0.04 per 1,000 gallons). Nonetheless, despite the relatively low costs, economies of scale negatively affect small water systems that have a smaller rate base to spread both capital and O&M expenses.

As for infrastructure, the American Society of Civil Engineers (ASCE) recently gave a grade of "D" to drinking water infrastructure, in its 2003 Progress Report for America's Infrastructure. EPA estimated in October 2002 that over the next 20 years, there would be a $535 billion funding gap nationally for water and wastewater infrastructure. The drinking water estimate alone was $265 billion, covering both capital and operations and maintenance costs. In November 2002, the Congressional Budget Office issued its own estimate of at least $25 billion (2001 dollars) annually for the same time period, consistent with

EPA's figures. EPA estimates California's drinking water infrastructure needs at approximately $1 billion annually over the next 20 years. EPA also predicted that per household costs to small water systems will be four times that of customers of large water systems -- those serving more than 50,000 persons.

Major Issues

There are several major issues facing drinking water treatment and distribution.

Access to Safe Drinking Water

The provision of safe drinking water is a fundamental preventative public health measure. DWR's recent report *Californians Without Safe Water,* found that over 81,000 California households may rely upon an unsafe source of water. In lieu of a connection to a public water system, many of these households may be obtaining their drinking water from shallow wells, springs, or hauled water supplies that are vulnerable to contamination. Moreover, many other households and schools, often in rural or low-income areas, are connected to small water systems that are less scrutinized by regulatory agencies. These small systems usually have limited funds and staffing to pursue improvements in drinking water quality, including the preparation of grant applications. Even for those households that are connected to a public water system, DHS reports that in 2001, over 40,000 people were served water from public water systems that had repeated violations of the coliform bacteria drinking water standard, and that over 700,000 people were served water in violation of the surface water filtration and disinfection regulations. In addition, nearly one million Californians were served water in 2001 from public water systems that had a "significant sanitary defect involving sewage."

Emerging Contaminants

New contaminants are often discovered and then regulated because of increased pollution, improved analytical abilities, and better understanding of health effects. In addition, the health effects of many known contaminants are re-evaluated--and re-regulated--in light of new information. For many emerging contaminants, there may not yet be treatment technologies available to remove them from drinking water. In fact, emerging contaminants may be created by treatment itself, for instance, when water utilities implement new methods or processes for disinfecting water. For such contaminants, only pollution prevention, or matching water quality to use, will adequately address water quality. For other contaminants, treatment options, such as membranes, may be available, but they are relatively expensive.

Risk, Demographic Changes

There are increasing numbers and proportions of immunocompromised individuals--as well as children and elderly--who are more susceptible than the general population, to the risks of waterborne disease and exposure to contaminants. At the same time, water agencies are responding to regulatory signals that require control of disinfection byproducts in treated surface water. Depending upon the treatment scheme employed, measures to reduce the probable long-term risks of cancer can be at odds with efforts to protect the public from known short-term risks from microorganisms.

Contaminant Interactions and Cumulative Effects

There is growing concern about the interactions and cumulative effects on human health of multiple contaminants in drinking water. Such effects are not addressed by current drinking water standards, which only regulate contaminants on an individual basis. Moreover, some contaminants, such as disinfection byproducts, present risks simultaneously through multiple exposure routes (e.g. ingestion, inhalation, and dermal). The CALFED Drinking Water Quality Program is attempting to address this concern via its

"Equivalent Level of Public Health Protection" strategy, which looks comprehensively at the total concentration of contaminants in drinking water, and integrates pollution prevention, alternative water sources and facility re-operation, and advanced treatment to reduce them.

Recreation

The state Department of Parks and Recreation forecasts an increasing demand for recreation on reservoirs, including drinking water terminal reservoirs, such as Lake Perris in Southern California. An increase in reservoir contamination, especially microbiological from body-contact recreation, can correspondingly increase the requirements of the treatment processes, in the treatment plants that a drinking water terminal reservoir feeds, and degrade the quality of tap water produced from these lakes.

Public Distrust

Public opinion surveys consistently suggest that Californians, across all socio-economic groups, poorly perceive and even distrust the quality of their tap water, often because of tap water taste, odor, or appearance, choosing instead to rely upon home treatment units and bottled water. Quite simply, improvements in water quality may not lead to improvements in public health if the public is not drinking the water. While some amount of bottled water use is certainly related to convenience or lifestyle choices, the poor perception of tap water is certainly a factor as well. However, the public may not have access to complete information about the relative safety of bottled and tap waters, and may be misplacing their trust in sales pitches for bottled water and home treatment units. Furthermore, students may be bypassing tap water in schools—when it's even available—in favor of less healthy beverage alternatives.

Affordability

Even though water treatment is a relatively small portion of a customer's water bill, increased costs are a concern for significant portions of the population. As costs increase, the relative burden on the household budgets of poor families will increase at rates greater than that of the general population. Moreover, the waterworks industry generally lacks lifeline rates for poor customers relative to other utilities, such as gas, electricity, and telephone. Paradoxically, for those economically disadvantaged consumers who choose to purchase bottled water, money spent on that commodity may be better spent on other life necessities.

Recommendations to Improve Drinking Water Treatment and Distribution

1. All Californians should have access to safe drinking water. Thus, the state should assist in funding drinking water and wastewater infrastructure needs in areas--including on tribal lands--without piped domestic water and therefore not covered by the state and federal Safe Drinking Water Acts. Further, the state should implement the recommendations of DWR's 2003 report, *Californians Without Safe Water*.
2. The state, local water agencies, and non-profit organizations should better educate the public about the actual and perceived risks of tap water, bottled water, and water produced by home treatment units. State and local water agencies should specifically improve outreach to and communication with vulnerable populations that may indeed be at a higher actual level of risk of waterborne disease or other health effects from drinking water contaminants. Doctors and other healthcare professionals, in whom the public may place their trust, should be involved in this effort.
3. Communities should have useful access to, knowledge of, and engagement in, drinking-water quality monitoring and assessment. In addition, decision-making at all government levels should be

transparent and involve affected communities, tribes, and general purpose local governments. Examples of vehicles for such access, knowledge, and engagement include citizen water quality monitoring programs, and water quality community advisory committees, at the local water system level.

4. The state should consider increasing the set-aside capacity building within the Drinking Water State Revolving Fund to the maximum allowed by EPA for these purposes. Systems that serve large proportions or numbers of vulnerable populations, such as schools, should receive funding priority. The state should increase its formal partnerships with non-governmental organizations that are experienced in assisting small water systems in grant and loan applications, in order to reduce the bureaucracy separating community access to information and funding, address the most pressing public health risks, and ensure an equitable distribution of grant and loan funds.
5. The state should implement guidelines for the design and operation of distribution systems to maintain system water quality. As a part of these guidelines, the state should ensure that public water systems are prepared for natural and man-made disasters, and are able to reliably maintain or quickly restore water quality in the aftermath of such disasters.
6. Water utilities must prevent possible cross-contamination of potable water from dual-plumbing of potable and recycled water distribution systems and other non-potable sources.
7. In response to continuing, legitimate concern from citizens, the state should monitor and resolve the potential health impacts of indirect potable reuse of recycled water.
8. The State Water Project and local agencies should only permit forms of recreation on terminal reservoirs that do not endanger the public health of those who drink the water produced from those reservoirs.
9. The state should coordinate its funding sources (e.g. the Drinking Water and Clean Water State Revolving Funds) in order to better address projects with multiple benefits – such as drinking water supplies threatened by contamination from septic systems. State water quality funding sources for small water systems should be closely coordinated with federal water quality monies, including funds available from the US Department of Agriculture.

Sources of Information

- *Bay-Delta Water Quality Evaluation*, California Urban Water Agencies, June 1998
- *Drinking Water into the 21st Century; Safe Drinking Water Plan for California, A Report to the Legislature*, California Department of Health Services, January 1993
- *Californians Without Safe Water, California 2002*, Department of Water Resources, 2002
- 2000 US Census
- USEPA Drinking Water Program, www.epa.gov/safewater/
- USEPA Needs Survey, www.epa.gov/OGWDW/needs.html
- Congressional Budget Office, www.cbo.gov/execsum.cfm?index=3983&from=1&file=ExecSum.htm
- Water Infrastructure Network, www.win-water.org/
- City of Fairfield
- Metropolitan Water District
- California Department of Parks and Recreation
- ASCE 2003 Progress Report for America's Infrastructure

Economic Incentives
(Loans, Grants, and Water Pricing)

Economic incentives are financial assistance and pricing policies intended to influence water management, including, for example, amount of use, time of use, wastewater volume, and source of supply. Economic incentives include low-interest loans, grants, and water pricing rate structures that water users factor into their water management decisions. Free services, rebates, and the use of tax revenues to partially fund water services also have a direct effect on the prices paid by the water users. In general, higher costs to water users tend to reduce water use. Also, government financial assistance can make subsidies by water agencies possible.

Economic incentives should be designed to support the suite of other strategies in a water agency's portfolio.

Current Use of Economic Incentives in California

The most prevalent water rate policy is for water agencies to recover direct water management costs, such as planning, operation, maintenance, and capital costs; administrative costs; other direct costs; and some indirect and environmental costs. Water rates are also commonly used to contribute to water agency capital investment accounts for funding anticipated projects. Water rates could be used to recover external costs such as third party economic or cultural costs. Other means available to recover costs include ad velorum taxes and revenues from bonds not repaid from water rates.

Because of existing policy, some agencies are not required to recover the full cost of development and maintenance. At the behest of congress, the US Bureau of Reclamation, for example, has traditionally not been required to recover all the costs of supplying water to agriculture. This is an example of a subsidy which was designed to achieve a social goal which affects water management; agricultural development in the West. Urban wastewater treatment facilities have also traditionally been relieved of full cost recovery because of substantial federal grant funding through the Clean Water Act.

Other examples of economic incentives include:

- The California Bay-Delta Authority, the Department of Water Resources, and the State Water Resources Control Board administer low-cost loans and grants programs to encourage agricultural and urban water conservation, urban water recycling, agricultural and urban groundwater storage, and conjunctive use projects.
- At the wholesale agency level, the Metropolitan District of Southern California has recently developed plans to expand its Local Resources Program, which provides a subsidy of up to $250 per acre-foot to its member agencies for water recycling, groundwater recovery, and seawater desalination. MWDSC charges a "water stewardship rate" to all its customers to subsidize individual retail agency programs with wider benefits.
- Incentives can include rebate programs for low-flush toilet installation, free water audits for residential landscape water management, free mobile lab services for increasing on-farm water use efficiency, or other innovative programs.

State-Managed Grants and Loans

Since 1984, Californians have approved six bonds propositions that provided $1 billion to fund local water supply and conservation programs (Propositions 25, 44, 82, 204, 13, and 50).

Water rates can take several forms. Water rate structures designed to recover costs can be fixed, uniform, or tiered. Both uniform and tiered rates can have a fixed component. Where water is unmeasured, only fixed assessments are possible. For example, water rates can be based on connection size for urban users or on acreage irrigated for agricultural users.

Rate Structure Examples

Fixed rate – The water user pays the same amount for water each month regardless of the amount of water use. This is common where water is unmeasured. Some call it a flat rate. *Example: $20 water bill each month.*

Uniform (or constant) rate – The water user pays the same for each unit of water. This requires measurement of water. *Example: $100 for each acre-foot of water.*

Tiered water rate – The water user pays a higher rate for each unit of water. Some call this increasing block rates. This requires measurement of water. *Example: $1 for the first 100 cubic feet, $1.50 for the second 100 cubic feet, $2 for the third 100 cubic feet, etc.* In some cases, agencies use declining block rates, where the water user pays a lower rate for each unit of water.

Most urban agencies in California are moving away from uniform rates and toward rate structures based on volume of water used. Many urban agencies have already adopted tiered rate structures where the unit water charge increases as water use increases; the more units of water use, the higher the charge for each subsequent unit. Some tiered water rate structures may have higher seasonal rates. In 1999, of 326 California urban water purveyors surveyed, about 45 percent had tiered rates, 42 percent had uniform rates, 11 percent had flat or other type rates, and 2 percent had declining block rates[1]. Some agricultural agencies, particularly concerned with drainage water management, have adopted tiered rate structures. Most apartment building owners don't individually meter their tenants, removing the effect of volumetric pricing on the tenants' water use.

While most residential wastewater treatment is currently charged at a flat rate, commercial and industrial users are more likely to be charged by wastewater volume (and, in some cases, the types of constituents in their wastewater).

Potential Benefits from Economic Incentives

A major purpose of economic incentives is to reduce water demands. This may produce environmental or social benefits, or avoid or delay construction of new water supply projects. When water costs increase, customers have a choice to either pay the higher water bill or find methods to use less water, such as using a broom or blower to clean sidewalks instead of a water hose. Residential and agricultural customers may purchase more efficient water using technologies, such as installing a drip irrigation system, or they may forego some water using activities, including removing some of their residential landscaping or agricultural acreage from irrigation.

Depending on the overall volume of water savings and the location of savings, economic incentives that produce more efficient water management practices can result in benefits or costs to the environment by changing water quality or the timing of diversions. Conversely, water rate policies that lower the cost of surface water during wet cycles can encourage storage in groundwater basins. Water quality improvements resulting from economic incentives can help farmers meet drainage water goals as well as

[1] 1999 California Water Charge Survey, Black & Veatch Corporation.

lower treatment costs and/or provide health benefits to urban users in addition to benefiting the environment.

Marginal-cost pricing is one strategy to promote more efficient water use. With marginal-cost pricing, customer rates would reflect the full cost of the last, and probably the most expensive, source of supply. In a less severe form, marginal-cost pricing for “new” customers — residents of new subdivisions, for example — might reflect the average cost of the additional supply needed for those customers. This price would be higher than that for existing customers.

Economic incentives can also be used to influence development of water supply augmentation or demand reduction programs. For example, grant funds from a state agency can reduce the effect on water rates of water recycling projects. Similarly, a wholesale water agency might make financial assistance available to its member agencies to encourage implementation of projects or programs that would benefit all member agencies. Financial assistance can also be used to achieve beneficial changes in water system storage, conveyance, and treatment operations. The willingness of a water agency to participate in water marketing can also be influenced by economic incentives.

Quantifying water benefits provided by economic incentives is difficult. Incentives act indirectly by influencing the adoption of strategies that directly affect water management. Determining potential water quantities would require assumptions about what strategies would result from those incentives and the quantities of water involved.

Potential Costs of Economic Incentives Policies

The only financial cost of an incentives program to a water agency is the cost of its creation and administration. Other costs would be associated with the adoption of water management strategies or water use behaviors _ including foregoing some water use _ that may result. The costs of the economic incentives will depend on how the incentives are integrated into the suite strategies in a water agency’s portfolio. As with other management strategies, economic incentives must be specific to the circumstances and water management goals of each individual water agency.

Major Issues Facing Additional Economic Incentives

The major issues facing the design of economic incentives are:

Selecting Appropriate Water Rates

A major consideration is determining what rates to charge customers while ensuring that costs of delivering the water and treating the wastewater are recovered. Also, managing water rate changes during water shortages can be challenging since incremental costs of supply can both increase dramatically and change rapidly, making it more difficult to recover costs. If regulations against collecting revenues in excess of costs remain in effect, some agencies would have to reduce their lower tier prices in order to charge higher costs at the higher tiers. This would tend to increase use by the lower-tier customers, an undesirable result from a water use management standpoint.

Currently, if a landlord wishes to charge tenants based on volume of their use, the landlord would have to comply with many of the same water quality regulations faced by utilities, including testing by experts. The EPA is currently seeking a rule change to remove this barrier to individual metering.

Funding for Loans and Grants

The availability of state funding can be intermittent. Funding methods that require direct legislative appropriation or approval of new water bonds could require several years lead time before funds are available.

Criteria for Loans and Grants Funding Approval

Historically, requests for loans and grants have exceeded available funding. Deciding which strategies and which agencies receive loans and grants requires development of ranking criteria to guide the allocation of funds.

Social Considerations

Economic incentives can affect social equity when those customers incurring the costs of subsidization through higher taxes or fees do not receive a fair share of the benefits that the subsidies are expected to generate. As another example, increasing the costs for agricultural water supplies may increase the efficiency of on-farm water use, but can also induce changes in crop patterns that result in lower farm employment. Communities dependent on farm production may be disproportionately affected. In the urban sector, if water rate changes reduce the use of ornamental landscaping, jobs that depend on establishing and maintaining that landscaping could be lost.

Regulations

Some water agencies are not permitted to collect revenues in excess of costs. Changes in regulations may be needed to implement a water pricing policy that works best for an agency. Some water agencies have regulations that prevent the use of water metering necessary for measuring and pricing volumes of water. Typically, loans and grants are constrained by bond language to strategies that lead to capital expenditures. Most loans and grants may not be used for developing non-capital strategies such as water rate changes.

Recommendations to Help Promote Economic Incentives

The state and water agencies should consider and evaluate economic incentives as an integral part of their package of management strategies. The following recommendations recognize that economic incentives will vary widely throughout California due to differences in local conditions:

1. Institute water rates that support better water management based on the unique conditions in each water district.
    - Implement appropriate measurement of all water uses in California, including urban metering in accordance with the recommendations of the CALFED appropriate measurement workgroups.
    - Use tiered pricing to the extent that it improves water management, including consideration of higher prices for water in excess of agricultural and urban vegetation management requirements.
    - Move as much of cost recovery from sources of revenue not related to water use (e.g., ad velorum taxes) and fixed water charges to variable charges in water service and wastewater treatment rates as is financially prudent.
    - Institute pricing incentives that encourage the sustainable use of groundwater.
    - Institute pricing incentives that reduce excessive deep percolation of water in agricultural drainage problem areas.

- Agencies adopting new water rates should clearly identify what they mean to water users and provide education, training, and technical assistance to water users to maximize the desired outcome of those policies.

2. Institute loans and grants that support better regional and statewide water management based on the unique conditions in each water district.
    - Develop ranking criteria for grant and loan awards to water agencies that consider economic, environmental, and equity issues, economic hardship, Public Trust, Environmental Justice, and the regional and statewide distribution of benefits in allocation of subsidy funds.
    - The grant and loan award process should account for the fact that some water agencies have limited funds and staffing to prepare applications.
    - Agencies receiving grants and loans should make information on the success of the programs/projects that they implement available so that the experience can be used to design better subsidy plans.
3. The state should provide technical assistance to local agencies in developing equitable and effective economic incentives to achieve local and statewide water management goals and objectives.
4. The state should develop guidelines and ranking criteria for grant and loan awards to water agencies that consider cost-effective water management, environmental and equity objectives. These guidelines and ranking criteria should account for the fact that some water agencies have limited funds and staffing to prepare applications.
5. The state should assist local agencies in using planning methods that maximize economic efficiency on a regional and statewide basis.

Information Sources

- CUWCC. "Setting Urban Water Rates for Efficiency and Conservation, a Discussion of Issues". October 1994.
- City of Los Angeles. "A Consensus Approach to Water Rates". June 1992. USSR. "Incentive Pricing Handbook for Agricultural Water Districts". April 1997.
- Reason Foundation. "Water-Utility Regulation: Rates and Cost Recovery". March 1993.
- Federal water recycling grant program.
- State conjunctive use, water use efficiency, and water recycling grants and loans programs.
- MWDSC Local Resources Program.

Ecosystem Restoration

Ecosystem restoration is the activity of improving the condition of our modified natural landscapes and biotic communities to provide for the sustainability and for the use and enjoyment of those ecosystems by current and future generations. Healthy aquatic and wetland ecosystems benefit California's native plant and wildlife populations and provide valuable goods and services that support our society and economy. Ecosystem restoration can include instream flow changes, habitat restoration, physical modification to water bodies, control of waste discharge in waterways, exotic species control, removal of barriers to anadromous fish migration, land and water acquisitions, and fire management.

California's ecosystems cannot be restored to the natural state, or even to pre-Gold Rush conditions. Instead, ecosystem restoration focuses on the rehabilitation of ecosystems so that they supply important elements of their original structure and function in a sustainable manner. Ecosystem protection and restoration should be viewed as the proper maintenance in a sustainable manner of California's natural infrastructure, with recognition of the importance of that infrastructure to the future of this state. Ecosystem restoration is included among the water management strategies in *Water Plan Update 2003* because it is linked with improvement of water supply reliability, and also because it is an important consideration for water managers as they pursue integrated resource management.

Over the past decade, the public has recognized the need to restore California's ecosystems, largely as a result of the public's awareness of the value of healthy rivers and other aquatic ecosystems. The desire to improve the conditions of those ecosystems was supported by the passage of bond issues, such as Propositions 204, 13 and 50. Local and regional restoration projects have multiplied in number. Hundreds of watershed alliances and regional ecosystem projects are in place throughout the state. Major river restoration projects are under way in every corner of the state, including the Los Angeles, San Joaquin, Truckee, Carmel, Sacramento, and Trinity Rivers, to name a few. Some of these projects are described in the regional reports of Volume 2.

The decade prior to publication of this update saw a remarkable transformation in water management in California. In 1993, water management was characterized by lawsuits, policy gridlock, and conflicts between those who sought to improve water supply reliability and those who sought to protect threatened and endangered species. Since then, the California Bay-Delta Program has served as an example of integrated resource management – improving water supply reliability while simultaneously restoring ecosystems – and seems far more likely to succeed than single-purpose pursuits.

Water development projects in the past have often had significant, if unanticipated, environmental impacts. Today, planning must include front-end investment to prevent ecosystem damage and long term maintenance costs. Future water management efforts could face conflict and opposition unless these efforts are accompanied by actions that contribute to the protection and restoration of ecosystem health. This strategy focuses on restoration of aquatic ecosystems because these are the ecosystems most likely to be affected by the actions of water projects. Furthermore, water projects play a critical role in the restoration of aquatic ecosystems because they can help ensure appropriate water supply, flow rate or flow pattern to facilitate restoration actions.

State water managers also have an important public trust responsibility to protect waters of the state for their environmental, recreational, and aesthetic values. Other strategies described in this chapter that relate closely to ecosystem restoration and public trust responsibilities include floodplain management, pollution prevention, matching water quality to use, and water-dependent recreation.

Ecosystem Data

Information on restoration projects, biological resources, and organizations involved in restoration can be found for many parts of the state. The Information Center for the Environment (ICE) is a cooperative effort of environmental scientists at the University of California, Davis, and collaborators at more than 30 private, state, federal, and international organizations interested in environmental protection. ICE has developed the Natural Resources Projects Inventory, a database of information on thousands of conservation, mitigation and restoration projects being developed and implemented throughout California. Also, the California Environmental Resources Evaluation System is an information system developed by the Resources Agency to facilitate access to a variety of electronic data describing California's rich and diverse environments. The California Legacy Project, a part of CERES, has supported conservation investment decisions in numerous ways, including: (1) identified a long-range strategy to conserve the most important natural resources in California; (2) assembled a digital atlas of key resources and stressors; and (3) reported on the status and trends of those resources.

Current Condition of California’s Ecosystems and Restoration Activity

California Rivers, A Public Trust Report (State Lands Commission, 1993) concluded that the health of California’s rivers is stressed and their viability as sustainable ecosystems is in peril. The report urged state agencies to undertake a comprehensive program of river basin and watershed protection and restoration. The same conclusions apply to many of California’s other aquatic ecosystems, including bays, estuaries, and lakes. The condition of California’s fisheries reveals the need for extensive improvement. Thirty-three fish populations are listed as threatened or endangered in California, with some in each of the hydrologic regions described in Volume 2. These populations include coastal and Central Valley runs of steelhead; spring-run and winter-run Central Valley Chinook salmon; Delta smelt; three species from the Colorado River; and several minnows, pupfish and suckers from the Klamath basin and southern deserts.

California’s ecosystems, particularly aquatic ecosystems, have been significantly modified over time. Hydraulic mining and gold extraction in the 1800s, dam construction and operation, pollution, flood control, urbanization, increases in Delta exports and upstream diversions, and introduction of exotic species have all contributed to the decline in ecosystem health. Ecosystem changes have caused a sharp decline in the abundance of things that society values, such as native and some non-native fish species. Ability to sustain various life stages of native fish is an example of a function that California rivers no longer provide as well as they once did. Human activities have also affected the structure of ecosystems. For example, rivers downstream of dams are deprived of the gravel supply from upstream that provides spawning habitat for species such as Chinook salmon.

One significant ecosystem stressor is the unintended impact of actions that we intentionally take. The California Environmental Quality Act recognizes that human activity may have unintended environmental impacts, and outlines procedures for project proponents to avoid, minimize, and mitigate these impacts. Mitigation for environmental impacts has become a common practice in California. Mitigation is similar to ecosystem restoration, but mitigation is intended to bring the level of ecosystem health back to what it was before impacts of a project occurred. By contrast, ecosystem restoration is intended to raise the level of ecosystem health.

Water projects can fall into this category of ecosystem stressors, and are usually controversial because of their unintended environmental impacts. It may not be possible to fully mitigate for the impacts of these projects. When impacts occur in aquatic ecosystems that are already severely degraded, it may be difficult to avoid endangered species conflicts or to build societal support for the project. Unlike other stressors whose impacts cannot be avoided, such as past damage from hydraulic mining, urbanization or introduced species, water projects can be stopped if society deems the environmental impacts to be unacceptably high. This is the situation that has often faced water managers in California over the past several decades. Water projects, including both large-scale projects such as the construction of major dams or increased exports through the Delta, as well as small local projects, have become the focus for opposition based on the projects' potential for environmental impacts.

More recently, resource managers have concluded that the most successful way to pursue either aquatic ecosystem restoration or water management is to integrate the two. This integration of project goals has the potential to reduce the conflict over water management actions, increase the support for ecosystem restoration and provide a more cost effective solution.

Beyond the pragmatic consideration of incorporating ecosystem restoration into water projects to increase the chance of success, water managers face a responsibility to protect waters of the state under the public trust doctrine. The public trust is a concept rooted in common law, stating that the state has the responsibility to hold certain resources in trust for the people and to exercise continuing supervision over these resources. Thus, it may not suffice to protect a natural resource in its current condition, if that condition represents a state of decline. Courts have upheld the public trust doctrine and affirmed the responsibility of resource managers to protect public trust values whenever feasible.

Within state government, several departments and boards share public trust responsibilities. The Department of Fish and Game coordinates, oversees, funds, and carries out restoration activities and plays a central role in carrying out public trust responsibilities. The State Water Resources Control Board regulates water rights and establishes standards for minimum stream flows. The Department of Water Resources, as the operator of the State Water Project, can propose, design, build, and operate water management facilities in ways that improve water supply reliability while restoring ecosystem health and protecting public trust values. No one of these agencies can be completely successful unless there is collaboration among all. See Volume 1, Chapter 2, for details on the public trust doctrine and values.

Benefits of Ecosystem Restoration

Restoration can result in improved flora and fauna condition, increased diversity and connectivity of habitat, recovery of endangered species, and improved watershed condition and trends. Restoration efforts can rehabilitate natural processes to support native communities with minimal ongoing human intervention. Restored functional habitats are likely to sustain reproduction, foraging, shelter, and other life stage needs of a community of fish and wildlife species. By setting our goals high – at the ecosystem level, rather than recovery of a handful of species – we improve our chances for long-term success by incorporating species relationships, such as between predators and prey, physical processes, genetic variability, and other factors that we don't fully understand.

The state's ecosystems, from mountain watersheds to coastal beaches, are California's natural infrastructure, and support our population and economic growth. Ecosystem restoration is an investment in improving the condition of California's natural infrastructure. As our understanding of the linkage between water management and the health of the natural infrastructure grows, the benefits of restoration to water supply reliability and water quality improvements are increasingly evident. As ecosystem restoration actions help increase the health and abundance of species currently protected under the state and federal Endangered Species Acts, there will be fewer ESA conflicts. As ecosystems such as wetlands and sloughs are restored, their natural pollutant filtering capabilities will improve water quality. As floodplains and seasonal lakes and ponds are restored, groundwater recharge can increase. The result will be a more reliable, higher quality water supply supported by a sustainable ecosystem.

The economic benefits that improved rivers, estuaries, wetlands, wildlife, beaches, and their surrounding habitats can have in the state may far exceed the investments for restoring ecosystems. Considering California lifestyle trends and travel and tourism as the major growth industry for the state, investments in ecosystem restoration actions may provide a high return on investment.

California's recreation and tourism industry – at $75 billion a year – is one of the state's largest industries. Next to the state's beaches, rivers are the second biggest attraction for California's recreation industry. Similarly, managed wetlands and wildlife refuges provide bird watching and hunting opportunities that contribute hundreds of millions of dollars annually to California's economy.

Costs of Ecosystem Restoration

A statewide summary of ecosystem needs and their costs does not exist. However, it is likely that the costs of restoration are higher than the costs of protecting existing healthy ecosystems. Costs of restoration can include research and monitoring, acquisition of land and water, cultivation and planting of native vegetation, and physical alteration of the landscape. The costs of river restoration can increase dramatically when channel alteration is required, such as filling in gravel pits or re-grading incised banks.

California voters have recently approved three bond issues that include funds to restore animal and plant life. As of the end of 2003, the California Bay-Delta Program has funded 400 projects at a cost of $490 million, and has committed $150 million per year toward ecosystem restoration.

Supplying water for ecosystem needs is often viewed as competing with supplying water for human needs, or responsible for increasing the cost of supplying human needs. While there are limits to the amount of water that can be withdrawn from a river ecosystem before its health and productivity are compromised, experience with integrating ecosystem restoration and water supply management is demonstrating their compatibility in many cases. As an example, in years 2001 through 2003 the Environmental Water Account of the California Bay-Delta Authority acquired about 900,000 acre-feet of water, at a cost of about $140 million, to protect at-risk fish species.

Major Issues Facing Implementation of Ecosystem Restoration

The major threats to aquatic and riparian habitat and freshwater biodiversity in California stem from physical changes associated with on-stream dams, diversions, levees and bank armoring; poor water quality, including temperature, dissolved oxygen levels and pollutants; and non-native invasive species. These issues are outlined further in the strategies for floodplain management, pollution prevention and watershed management in this chapter. Beyond those direct physical changes, this section describes other issues and challenges facing restoration efforts.

Integrated Resources Planning

Unlike single-purpose planning, project designs that incorporate diverse interests can take longer, cost more and require better knowledge of key ecological elements and processes.

Assessment of Environmental Flows

Knowledge of effects of different flows on the health of aquatic and riparian ecosystems is incomplete. Data and analytical tools to measure the adequacy of flows are insufficient.

Scientific Uncertainty

Restoration science is a work in progress. Rarely do we have all the scientific information on a species, much less an ecosystem, to identify an exact course of action that will restore natural communities and processes. When precious resources and endangered species are involved, we often do not have the time or money to fully develop our scientific understanding before action is needed. Yet, the uncertainty can lead to hesitation and delay.

Sound, Accessible Data

There is no complete inventory of ecosystems and their health. Key criteria to prioritize conservation actions are lacking, scattered or incompatible for comparison. There is also no reporting system and incomplete metrics for evaluation of the outcome of various restoration and management strategies. This is necessary for more efficient investment of public funds.

Effectiveness and Efficiency of Restoration Actions

The previous issue statements make it clear that assessment of the effectiveness and efficiency of actions taken to restore and protect aquatic ecosystems is often complex and difficult. Effectiveness is the amount of benefit gained (e.g., an increase in abundance of a species). Efficiency can be thought of as the effectiveness per unit of expenditure (e.g., money or water). Effectiveness and expenditure may not correspond one-to-one, often because factors other than the applied money and water influence the degree of restoration achieved. The perception of wide variations in efficiency motivates a search for the more efficient alternatives. Without agreement on which alternatives those might be, opposition to further commitments, especially of water, will continue.

Funding Uncertainty

Ecosystem restoration efforts are often long-term and need long-term financing. Although public funds are available, they may be sporadic and thus unreliable, and are subject to intense competition. In contrast, water supply projects could rely on user fees to recover costs.

Gravel and Sediment

Dams retain sediment, including gravel, which is a critical element in river ecosystems. Furthermore, conventional bank protection prevents the erosion that could provide a local supply. Without a natural mechanism for replenishment of sediment, gravel must come from elsewhere. Locating sediment sources, mining gravel without causing more environmental damage and paying for long-term sediment management are significant challenges to restoring the natural functions and values of rivers below large dams.

Recommendations for Ecosystem Restoration

1. DWR, DFG and SWRCB should work together to publish comprehensive assessments of in-stream flow needs on California rivers, similar in scope to studies on the Feather and American rivers. The assessments should identify bodies of water that need improved flows, in terms of volume, timing, duration, etc.
2. The Resources Agency and Cal-EPA should work with their respective departments, boards and commissions to ensure and promote independent science in decision-making.
3. The Resources Agency should continue to support development and use of statewide databases, analytical tools and evaluation criteria, such as the Natural Resource Project Inventory and a follow-up to the Legacy project, that can provide information to planners and decision-makers and identify priorities for restoration. This investment should provide a coordinated and comprehensive statewide implementation plan for restoration actions in each region.
4. The Resources Agency should support further scientific research on the relationship between flow dedication and water-independent actions to achieve desired restoration. A step in this direction was the publication of a report by Deason et al. (2004) of the Graduate School of Public Policy at UC Berkeley, "Considering water use efficiency by the environmental sector." The report (see Volume 4) identifies ways to measure and compare—albeit in general terms—the efficiency of different uses of managed environmental water.
5. The Department of Fish and Game, with the Department of Conservation and DWR, should investigate and resolve key issues regarding long-term coarse sediment supplies for ecosystem needs. This investigation should identify sources of sediment, replenishment processes that will sustain themselves and potential mercury contamination.

Integrated Resources Planning

DWR will incorporate ecosystem restoration as an objective in water management projects, or will partner with restoration projects, to achieve net environmental benefit from water management actions. This is consistent with the commitments that DWR has made in the California Bay-Delta Program. DWR will develop guidelines for helping local water managers and planners pursue the same multiple-objective approach, including incorporation of fish and wildlife benefits into projects. See Volume 1, Chapter 2, for more recommendations to promote integrated resource planning.

Funding

As part of the FY 03-04 Budget, the Department of Finance proposed and the legislature adopted the following Budget Bill text: "It is the intent of the Legislature that the California Bay-Delta Authority submit a broad-based Bay-Delta user fee proposal as part of the 2004-05 Governor's Budget, consistent with the beneficiary-pays principle specified in the CALFED Record of Decision."

Such a fee was described in the Implementation Plan appendix to the CALFED Record of Decision, which said "For the Ecosystem Restoration Program, the CALFED agencies propose a combination of State funding (including Proposition 204 funds), Federal funding, and user fees…the CALFED agencies will work with local interests to develop State legislation to create a broad-based user fee that will generate approximately $35 million annually."

Information Sources

- California State Lands Commission. 1993. California Rivers, A Public Trust Report. 334 p.
- California Department of Fish and Game. 2003. California's Plants and Animals. http://www.dfg.ca.gov/hcpb/species/t_e_spp/tespp. shtml
- CALFED Bay-Delta Program. 2000. Strategic Plan for Ecosystem Restoration. x, 73 p.

Floodplain Management

Floodplain management is a term used to describe actions on the floodplain intended to reduce risks to life and property and to provide benefits to natural resources. Floodplain management recognizes that managing activities within the floodplain to accept periodic flooding is, in many cases, a preferred alternative to keeping rivers in their channels and off their floodplains. Seasonally-inundated floodplains provide essential habitat for hundreds of species of plants and animals, many of them dependent on periodic floods. There are also economic, agricultural and societal benefits to maintaining connections between rivers and their floodplains, including groundwater recharge. Some examples of floodplain management objectives include:

- Minimize impacts of flood flows to buildings, farmland.
- Maintain or restore natural floodplain processes.
- Remove obstacles within the floodplain, voluntarily or with compensation.
- Educate the public about avoiding flood risks and plan for emergency procedures.
- Prevent activities that interfere with the safe operation of the flood management systems.

Current Floodplain Management in California

In the past, many flood management projects within floodplains were developed to carry out single-purpose objectives, mainly to reduce property damage, without considering the importance of flooding in maintaining a healthy natural environment. Likewise, some ecosystem restoration projects were carried out without sufficient consideration of long-term floodway maintenance requirements. Such single-purpose projects are no longer considered the preferable approach. Instead, governmental agencies and the private sector are likely to garner the resources and public support for projects only if they achieve multiple benefits. Urban and regional planners are recognizing the value of floodplains by directing development away from functional floodplains. This avoids or minimizes the need for major flood control structures.

A voter-approved bond issue, Proposition 13, authorized funds for a flood protection corridor program. The program supports projects that provide non-structural flood management and either preservation of agricultural land or preservation or enhancement of wildlife habitat. A second bond issue, Proposition 50, contains additional incentives for watershed-based management approaches.

In 2000, the governor signed AB 1147, which recommended the creation of the California Floodplain Management Task Force. In February 2002, the governor delegated authority to DWR to convene the task force. With broad membership from government and stakeholders, the task force looked for ways to reduce flood damage and maximize the benefits of floodplains. The task force submitted its report in December 2002 with numerous recommendations (see the sidebar on following pages) to promote multi-objective management of floodplains.

The Designated Floodway Program of the State Reclamation Board reduces the impact of floods by preserving the reasonable flood-passage capacities of natural watercourses and floodways in the Central Valley of California. The program restricts the use of lands in Designated Floodways to agriculture, recreation and habitat, and thus retains the historical patterns of flooding. There are more than 1,300 miles of designated floodways in the Central Valley.

The U.S. Army Corps of Engineers and the State Reclamation Board are examining the feasibility of a multipurpose project on the Sacramento River to include ecosystem restoration, flood damage reduction and recreation around Hamilton City. The project could restore natural floodplain processes by construction of a setback levee and restoration of about 1,200 acres of riverine habitat.

The priorities of the CALFED Bay-Delta Program Ecosystem Restoration Program include restoration of floodplain habitat, riparian corridors and dynamic river processes such as meander belts. The ERP identifies opportunities to mimic natural flow regimes through reservoir releases; mimic natural flows of sediment and woody debris; and provide sufficiently high flows to inundate floodplain surfaces. The program recognizes that reconnection of rivers with their floodplains may be essential for recovery of numerous at-risk species.

An example of successful multiobjective floodplain management is in the Yolo Bypass. The bypass was established for use as a floodwater corridor in the floodplain of the lower Sacramento River basin. It is also intensively cultivated outside the flood season, and its rice fields double as habitat for waterfowl and wading birds. Parts of the bypass are managed for outdoor recreation, including hunting and fishing. Portions have been planted to riparian forest, with no significant loss of flood-carrying capacity. Management of the floodplain also provides spawning and rearing areas for native fishes. In addition, several modifications to water control structures are planned to improve or restore fish passage through the Bypass.

Benefits of Floodplain Management

Floodplain management can provide a wide array of safety, ecosystem and economic benefits. Floodplain management can reduce potential for loss of life, improve ecosystem functions and reduce flood damages to property by encouraging sustainable land use decisions along river corridors. By making better land use decisions, more open space, such as agriculture and native habitats, could be maintained. Controlling development within the floodplain, and even removing some damageable property from the floodplain, can significantly reduce potential future flood risk to people and property. Periodic inundation of the floodplain can provide rearing habitat that favors native fishes over exotics. Floodplain management that reconnects the river to portions of the floodplain can increase geomorphic processes, provide for more diverse habitats, and allow a restored ecosystem that is self-sustaining. This reconnection of the river with its floodplain can also increase groundwater recharge, benefiting groundwater supplies and water management.

Costs of Floodplain Management

Proposition 13 set aside $57 million for the Flood Protection Corridor Program. The program has funded or allotted funds to 19 projects, covering about 20,000 acres of habitat and agricultural lands. Many of the costs of floodplain management are in planning, mapping, and emergency preparations in the floodplain. Construction costs depend on site specific conditions and objectives but can include structural improvements such as setback levees and elevating, or removing, damageable property.

California Floodplain Management Task Force Recommendations Summary (Dec 2002)

The Task Force recommendations are organized into three categories: Better Understanding of and Reducing Risks from Reasonably Foreseeable Flooding; Multi-Objective Management Approach for Floodplains; and Local Assistance, Funding, and Legislation.

Better Understanding of and Reducing Risks from Reasonably Foreseeable Flooding

1. Awareness Floodplain Mapping - The State should expand its Awareness Floodplain Mapping Program for use by local governments and the public.
2. Future Build-Out Mapping - Local and State agencies preparing floodplain maps should consider current and future planned development.
3. Watershed-Based Mapping - Wherever practical, floodplain maps should be prepared on a watershed basis.
4. Geographic Information System (GIS)-Based Flood Maps - Local, State, and federal agencies should create, develop, produce, and disseminate compatible GIS-based flood maps.
5. Alluvial Fan Floodplains - Priority for alluvial fan floodplain mapping should be given to those alluvial fan floodplains being considered for development. The State should convene an alluvial fan task force to review information, determine future research needs, and develop recommendations specific to alluvial fan floodplain management.
6. Stream Gaging and Monitoring - DWR and other agencies should sponsor projects in cooperation with the United States Geological Survey (USGS) to install real-time gages in priority locations throughout California.
7. Repetitive Losses - Local agencies should work with the Governor’s Office of Emergency Services (OES) and DWR to identify repeatedly flooded structures and inform qualifying residents of voluntary programs to prevent future flood losses.
8. Flood Warning and Response Programs - The State should increase assistance to local agencies to improve flood-warning programs specific to each watershed.
9. Flood Insurance Rate Map Issues – Decision-makers should gather information and data beyond Flood Insurance Rate Maps (FIRMs) to better assess reasonably foreseeable floods.
10. Exceeding NFIP Floodplain Management Requirements - Local communities should be encouraged to require new and substantially improved buildings to have their lowest floor elevations to be at least one foot above the NFIP’s base flood elevation, factoring in the effect of full build out of the watershed.
11. Executive Order - The Governor’s 1977 Executive Order should be updated.
12. State Multi-Hazard Mitigation Plan - DWR, OES, and other agencies should incorporate into the State Multi-Hazard Mitigation Plan floodplain management measures that will meet Federal Emergency Management Agency (FEMA) requirements.
13. Multi-Hazard Mapping - OES should coordinate with other hazard mapping efforts to develop GIS-based multi-hazard advisory maps and distribute them to local governments and the public.
14. State Building Codes – Ensure that the California Building Standards Code meets, at minimum, NFIP requirements. Ensure that other State codes applicable to public buildings meet, at a minimum, NFIP requirements. Ensure that any local code adoptions or amendments and any development approvals meet, at a minimum, NFIP requirements.

Multi-Objective-Management Approach for Floodplains

15. Multi-Objective-Management - A “M-O-M” approach to flood management projects should be promoted.

16. Flood Management Approaches to Ecosystem Restoration and Agricultural Conservation - Flood management programs and projects, while providing for public safety, should maximize opportunities for agricultural conservation and ecosystem protection and restoration, where feasible.
17. Nonstructural Approaches, Restoration, and Conservation of Agriculture and Natural Lands- In planning new or upgraded floodwater management programs and projects, including structural projects, local and state agencies should encourage, where appropriate, nonstructural approaches and the conservation of beneficial uses and functions of the floodplain.
18. Tools for Protection of Flood Compatible Land Uses - The State should identify, develop, and support tools to protect flood-compatible land uses.
19. Protection of Floodplain Groundwater Recharge Areas - Permitting agencies should consider the impacts of land-use decisions on the capacity of the floodplain to recharge groundwater.
20. Vector Control – During the planning and development of ecosystem restoration projects, the costs and impacts involved with vector control and with monitoring related to mosquito-transmitted diseases should be considered.
21. Multi-Jurisdictional Partnerships - The State should encourage multi-jurisdictional partnerships when floodplain management projects are planned and implemented.
22. Watershed Monitoring - The State and others should financially support the monitoring of flood management projects on a watershed level.
23. Proactive and Adaptive Management of Floodplains - State and local agencies should manage floodplains proactively and adaptively by periodically adjusting to current physical and biological conditions, new scientific information, and knowledge.
24. Best Management Practices - DWR should work with stakeholders to identify, monitor, and update voluntary BMPs for multi-objective floodplain management.
25. Training, Education, and Professional Certification - The State should encourage the inclusion of multi-objective floodplain management curricula in college and university degree programs.
26. Coordination among Agencies and Groups - The State should encourage and create incentives for additional coordination among stakeholders.
27. State General Plan Guidelines - The *State General Plan Guidelines* should be updated to reflect the California Floodplain Management Task Force recommendations, as applicable, and to reflect other programs, policies, and standards, including the NFIP, for floodplain management.

Local Assistance, Funding, and Legislation

28. New and Existing Funding Sources - The State and local governments should encourage federal, State, local, nongovernmental, and other private cost sharing to achieve equitable and fair financing of multi-objective floodplain management actions and planning.
29. Task Force Recommendation Priorities - DWR and The Reclamation Board should lead the development of a consensus process, involving appropriate stakeholders, to identify criteria and prioritize the implementation of Task Force recommendations, given the expected expenditures, using existing and new funding sources.
30. Department of Water Resources Outreach Programs – DWR should expand outreach programs to include public service announcements to increase public awareness of floodplain values, flooding hazards, public safety, and hazard mitigation measures.
31. Designated Floodways - DWR and The Reclamation Board should include, in the Community Assistance Workshops, information on the Reclamation Board's current authority to adopt and update designated floodways in the Central Valley. The Reclamation Board should work with stakeholders to identify, if any, a list of Reclamation Board regulations that are impediments to flood-compatible uses within the floodway and recommend specific revisions.

32. State Floodplain Management Assistance to Local Governments - The State should provide additional resources to continue and expand implementation of the State's floodplain management programs, including full support of the Community Assistance Contact program.
33. National Flood Insurance Program Compliance Encouragement – Public agencies not subject to local government floodplain management requirements or the Governor's Executive Order on Floodplain Management should comply with NFIP requirements.
34. Community Rating System – DWR should educate local officials and the public about the elements and benefits of the Community Rating System (CRS) insurance-rate adjusting program.
35. State CRS Program Coordinator - DWR should designate a State level CRS Program Coordinator familiar with State agencies and local governments that use the CRS program.
36. Interagency Barriers - The Reclamation Board should work with the Corps of Engineers, State agencies, local sponsors and interested parties to identify interagency barriers to efficient implementation of multi-objective flood management projects and to develop options to overcome those barriers.
37. California Environmental Quality Act Local Analysis Improvement – DWR should provide technical assistance to local agencies and practitioners with a practical, step-by-step CEQA flood hazard and impacts assessment guide.
38. Establishment of a California Floodplain Management Advisory Committee - DWR should sponsor a floodplain management advisory committee composed of local and State government representatives, floodplain managers, and other stakeholders, to develop additional recommendations to improve floodplain management practices.

Issues in Floodplain Management

Single-Purpose Approach to Floodplain Management

Due to the uncertainty of predicting flood flows, it is difficult to plan a flood damage reduction project that could assure long-term protection. In addition, it is difficult to obtain permits for single-purpose projects. Integration of multiple objectives, including public safety, flood damage reduction, agricultural conservation and ecosystem protection and restoration, require more time and collaboration among diverse interests than single purpose projects.

Floodplain Connectivity and Inundation

Common flood management and erosion control measures, such as levees and bank armoring, separate river channels and flows from historic floodplains. A challenge for floodplain and riparian ecosystem restoration is to reconnect the floodplain with the stream and still prevent damage from floods and soil erosion. This is especially difficult and costly where houses, highways, and other encroachments could potentially sustain damage and reduce flood-carrying capacity. Restoration of large river flows is constrained below dams where regulated maximum release levels are too low to produce desired results.

Recommendations for Floodplain Management

1. DWR and The Reclamation Board should lead the development of a consensus process, involving appropriate stakeholders, to identify criteria and prioritize the implementation of Task Force recommendations, given the expected expenditures, using existing and new funding sources (see above sidebar on Task Force Recommendations).

Information Sources

- CALFED Bay-Delta Program. 2000. Strategic Plan for Ecosystem Restoration.
- California Floodplain Management Task Force, 2002. California Floodplain Management Report.

Groundwater Remediation/Aquifer Remediation

Groundwater remediation involves extracting contaminated groundwater from the aquifer, treating it, discharging it to a water course, or using it for some agricultural or municipal purpose. It is also possible to re-inject the treated water back into the aquifer.

In the process of groundwater remediation, the groundwater flows through the aquifer toward the extraction wells where it is removed for treatment. If recharge of the aquifer continues, this flow provides a flushing action that may eventually remove most of the contaminants from the aquifer. This is also called the 'pump and treat' method of remediation. Pump and treat methods transfer the contaminant to either the atmosphere or a filter material. If a volatile material is transferred from the groundwater to the atmosphere, permits must be obtained from the appropriate air pollution control district or agency for the amount to be transferred. If a filtration medium is used, such as granular activated carbon (GAC), the GAC must be disposed of as a hazardous waste. If the GAC is regenerated, the waste from that process must be disposed of as a hazardous waste. If the contaminant is radioactive, such as uranium, then residuals may need to be disposed of as radioactive waste.

Aquifer remediation is usually accomplished by treating the groundwater while it is still in the aquifer, using *in situ* methods involving physical or chemical treatment, biological treatment, or electrokinetics.

Another term used for either groundwater or aquifer remediation processes is 'groundwater restoration.' Whatever the treatment method (see Table 1), it must be suited to the chemical (see Table 2) that has contaminated the aquifer. Light, non-aqueous phase liquids (LNAPLs), such as hydrocarbons, float on the surface of the groundwater. Dense, non-aqueous phase liquids (DNAPLs), such as trichloroethylene (TCE) have a specific gravity greater than water and sink to the bottom of the aquifer. Other contaminants, such as methyl tertiary butyl ether (MTBE), may be miscible in water and are in solution in the groundwater. Even with LNAPLs and DNAPLs, some of the contaminant dissolves within the groundwater in the aquifer.

Information for this write-up was provided by California Department of Health Services, Division of Drinking Water and Environmental Management; and by California State Water Resources Control Board, Division of Clean Water Programs.

Current Groundwater Remediation in California

Most remediation in California involves groundwater remediation; very little aquifer remdediation takes place. There are approximately 18,500 sites in the state where active cleanup of contaminants is ongoing. Regulatory oversight of these cleanups is by Regional Water Quality Control Boards (Regional Boards), the Department of Toxic Substances Control (DTSC) or local agencies. About 15,000 of these sites have had a petroleum release from a leaking underground storage tank (UST) system. A petroleum release is usually detected by analyzing for total petroleum hydrocarbons (TPH) and the more soluble constituents in fuel (benzene, toluene, ethyl benzene, and xylene, commonly called BTEX). In addition to these, MTBE can be found at former leaking UST sites. Groundwater cleanup at petroleum sites almost always focuses on reduction of BTEX and MTBE because most other components of petroleum are only very slightly soluble in water and do not migrate far from the original source of the leak.

In general, cleanup for the vast majority of contaminant sites involves excavation, free-product removal if applicable, soil vapor extraction, in situ remediation, or a combination of these remediation methods. Pump and treat methodology tends to be expensive and is not employed when other effective remediation options are available. The discharge from a pump and treat system may also require a discharge permit issued by a Regional Board.

Approximately 800 sites in California use pump and treat systems. Approximately one third of these are at UST sites, where shallow groundwater is typically affected. The treated flow volumes are on the order of 10-20 gallons per minute. At a small number of sites the volume treated can be millions of gallons per day.

Volatile organic compounds (VOCs) such as TCE and tetrachloroethylene (PCE) (see Table 1) are being removed from groundwater in Los Angeles, from the San Gabriel basin. VOCs are also being removed in Santa Clara County. Often these cleanups are associated with federal Superfund projects, e.g., the Glendale Operable Unit (OU), or the Burbank OU.

Perchlorate is being removed by ion exchange and biological treatment in Sacramento and San Gabriel basins. In Sacramento and Santa Clara, the treated water is released into a surface water channel, whereas in San Gabriel, the treated water is pumped into the public water supply distribution system.

Table 1—Types of treatment
Pump and treat – groundwater remediation
Activated alumina Biological Blending Coagulation/filtration Granular activated carbon, GAC Ion exchange, IX Lime softening Packed tower aeration (air stripping) Reverse osmosis, RO Ultra-violet photoionization
In-situ – aquifer remediation
Air sparging Bio-sparging Bio-venting Cosolvents Electrokinetics Electron acceptors (nitrate, sulfate, ferric ions) Electron donors (to degrade chlorinated hydrocarbons) Fluid cycling Hydrofracturing/Pneumatic fracturing Soil vapor extraction Surfactant enhancements Thermal enhancements Treatment walls Vitrification

Table 2—List of contaminants*
1,2-Dibromo-3-chloropropane, DBCP 1,2-Dichloroethane 1,2,3-Trichloropropane, 1,2,3-TCP Arsenic, As Carbon tetrachloride, CTC Ethylene dibromide, EDB Methyl tertiary butyl ether, MTBE N-Nitrosodimethylamine, NDMA Nitrate as NO_3 Nitrate + Nitrite as N Perchlorate, ClO_4 Tetrachloroethylene, PCE Total petroleum hydrocarbons, TPH e.g, hexane, jet fuels, mineral oils, benzene toluene, xylenes, naphthalene, fluorene Trichloroethylene, TCE Uranium, U
* Some may also be called by other names

Besides the groundwater remediation projects mentioned above, there are drinking water treatment projects for VOCs, including TCE, PCE, that are operating in various water systems (see Table 3). The gasoline additive MTBE is being treated in the City of Santa Monica, and in several smaller systems. Arsenic treatment is occurring in a few water systems to meet the current MCL of 50 micrograms per liter. In 2006, the new federal MCL of 10 micrograms per liter becomes effective, and it is predicted that additional water systems will be required to treat to remove arsenic systems. Pesticides, especially 1,2-

dibromo-3-chloropropane (DBCP) and ethylene dibromide (EDB), are being removed in the San Joaquin Valley and southern California.

Nitrates in groundwater are being blended or treated in most areas of the state where agriculture has been active, either in the past or today, and wherever there are high concentrations of septic tank treatment and disposal systems.

Potential Benefits from Remediation of Groundwater

The potential benefits of remediating contaminated groundwater so the water can be used as a part of the available water supply are:

- An additional water supply is available that would not be available without remediation
- The cost of buying an alternative water supply is avoided
- Eventually, through the flushing action, the aquifer may be cleaned up to the point that treatment is no longer required

Table 3--Locations of groundwater sources of drinking water with selected detected contaminants
Information provided by California Department of Health Services,
Division of Drinking Water and Environmental Management

Contaminant	Counties Affected (# of sources with detections)*	Types of Treatment Used	Examples: Water Systems to Contact for Additional Information
Regulated Contaminants			
Inorganic Chemicals			
Arsenic (current MCL – 50 ppb, **	Kern (10), Kings (13), San Bernardino (7), Sonoma (6), Nevada (5), Sutter (5), Los Angeles (4), Mono (4)	activated alumina; ion exchange (IX), reverse osmosis (RO), (others with limitations—see 22 CCR § 64447.2), blending	Edgemont Acres MWD; Boron CSD; Mt. Weske Estates MWC; City of Signal Hill
Arsenic (federal MCL, effective 2006 = 10 ppb)**	Kern (115), San Bernardino (70), Los Angeles (58), San Joaquin (56), Kings (37), Sacramento (37), Sutter (29), Sonoma (24), Riverside (20), Madera (15), Monterey (14), Fresno (13), Nevada (12), Tulare (12), Merced (10), Mono (9), Stanislaus (9), Napa (8)		
Nitrate as NO3	Los Angeles (171), San Bernardino (108), Riverside (79), Kern (64) Monterey (48), Fresno, Orange	IX, RO, blending	McFarland MWC, City of Pomona; Southern California Water Company; San Gabriel County Water District; CWS-Salinas; City of Fresno; Bakman Water Company; City of Garden Grove; City of Tustin
Nitrate + Nitrite as N	Los Angeles (80), San Bernardino (58), Riverside (31), Tulare (17), Ventura (13)		
Radioactivity			
Uranium	San Bernardino (46), Kern (38), Stanislaus (28), Riverside (28), Madera (20), Los Angeles (19); Monterey	IX, RO, lime softening, coagulation/ filtration	Cal Water, Lakeland; CWS-Salinas
Volatile Organic Chemicals			
Carbon tetrachloride	Los Angeles (95)	granular activated carbon (GAC), packed tower aeration, blending***	San Gabriel Valley Water Company; City of Monterey Park; La Puente Valley CWD
1,2-Dichloroethane	Los Angeles (90), El Dorado (10)		Southern California Water Company; La Puente Valley CWD
Methyl tertiary butyl ether (MTBE)	Los Angeles (6), Kern (5), Monterey, San Mateo, Madera		City of Santa Monica; Cal-Am WC – Montara; Riverview WD; CWS-Salinas; Yosemite Spring Park Utility Company
Tetrachloroethylene (PCE)	Los Angeles (152), San Bernardino (27), Sacramento (8), Kern (6), Fresno (5), Monterey		City of Burbank; San Gabriel Valley Water Company; City of Monterey Part; EPA-Whittier Narrows OU; City of Whittier; Southern California Water Company CWD-Salinas; La Puente Valley CWD

Trichloroethylene (TCE)	Los Angeles (196), Fresno (17), Riverside (14), San Bernardino (10), Butte		City of Burbank; City of Glendale; Cal Water Service Co, Chico; La Puente Valley CWD
Pesticides			
1,2-Dibromo-3-chloropropane (DBCP)	Fresno (121), San Joaquin (35), Tulare (35), San Bernardino (34), Madera	blending, GAC	City of Fresno; City of Clovis; City of Sanger; CalWater, Visalia; City of Lodi; City of Madera
Ethylene dibromide (EDB)	Fresno (15), Kern (11), San Joaquin (5), Madera	blending, GAC, packed tower aeration	City of Fresno; City of Madera
Unregulated Contaminants (No MCL)			
Inorganic chemical			
Perchlorate (MCL to be established—see DHS website for status)	Los Angeles (134), San Bernardino (80), Riverside (61), Orange (31), Sacramento (13), Tulare (8), Santa Clara (7)	IX, biological, blending	California Domestic WC; La Puente Valley CWD; City of Redlands; San Gabriel Valley WC-Fontana; City of Riverside; City of Colton; City of Rialto; So Cal Water Co., So San Gabriel; City of Morgan Hill
Semivolatile Organic Chemical			
N-Nitrosodimethylamine (NDMA)	Los Angeles (~5)	UV photoionization	San Gabriel Valley Water Company; City of Industry; La Puente Valley CWD
Volatile Organic Chemical/Pesticide			
1,2,3-Trichloropropane (1,2,3-TCP)	Kern (75), Los Angeles (29), Fresno (23), Tulare (18), San Bernardino (16), Merced (13); Riverside (7), San Joaquin (7), San Diego (6), San Mateo (5), Stanislaus (5)	see VOCs above	City of Burbank

* The numbers of sources are from the DHS database, including analyses reported 1994-2002 (see www.dhs.ca.gov/ps/ddwem/chemicals/monitoring/results94-02.htm except for MTBE, perchlorate, and 1,2,3-TCP, which are through 2003 www.dhs.ca.gov/ps/ddwem/chemicals/chemindex.htm. Arsenic data are from 2000-2002 /www.dhs.ca.gov/ps/ddwem/chemicals/arsenic/newmcl.htm, and the NDMA estimate is from the narrative at www.dhs.ca.gov/ps/ddwem/chemicals/NDMA/history.htm. For "Regulated Contaminants" the number in parenthesis represents detections greater than MCLs. For "Unregulated Contaminants of Interest" the number represents overall detections. In general, counties with only a few detections are not included, unless an example of a water system providing treatment is provided in a particular county. For more information on drinking water treatment technologies, contact the local DHS drinking water office (see the DHS website for office locations), or contact specific water systems that are addressing a contaminant problem.

**Arsenic currently has an MCL of 50 ppb. In 2006, compliance with a new federal MCL of 10 ppb is required. This will increase the number of sources will detections greater than the MCL from a total of about 70 80 to over 600.

***some systems are or may be considering use of advance oxidation processes, such as ultraviolet, or ozone for VOC treatment.

Potential Costs

The cost of remediating groundwater includes:

- Cost of characterizing the groundwater or aquifer, in terms of all the contaminants present
- Capital cost of the system, whether groundwater or aquifer remediation
- Operation and maintenance costs during the life of the project; remediation may be required for a long time

Except for responsible parties reimbursed by the Underground Storage Tank Cleanup Fund (Fund), it is difficult to estimate the cost of cleaning up contaminated sites. However, the Fund reimburses approximately $180 million annually to eligible claimants, It is estimated that major oil companies that have not been reimbursed are expending between $50-$100 million annually on their sites. Therefore, costs associated with the cleanup of all UST sites in California appear to easily exceed $300 million annually. The cost to clean up an individual UST site typically ranges about $100,000 - $200,000. The cleanup of UST sites with MTBE is costing significantly more than the average, with reimbursements as high as the Fund limit of $1.5 million per site.

The cost of cleaning up non-UST sites is also highly variable. A site where solvent contamination has reached groundwater may require continuous pump and treat operation for decades and cost millions of dollars.

Groundwater remediation avoids the costs of losing the aquifer as a water supply. These avoided costs include:

- Cost of an alternative water supply
- Long-term foregone profits and taxes from businesses and activities that decide not locate in the basin because of water shortages
- No opportunity for development of residential areas because there is no water supply available
- Contaminant may spread further, requiring greater and more costly remediation in the future

Major Issues Relating to Groundwater Remediation

The major issues facing groundwater and aquifer remediation are:

Water Quality

Several groundwater quality issues complicate remediation efforts. The types and the concentration of the constituents vary from aquifer to aquifer. Contaminated water associated with a hazardous waste facility, Superfund site, and other sites may contain a variety of regulated and unregulated contaminants. Contaminated water may be poorly characterized, in terms of the contaminants that are present and locating the dimension of the plume is costly. The sources of the contamination need to be found and eliminated (or the amount of contaminated discharge reduced), so that the groundwater basin can be cleaned up. There is always potential for other contaminants being detected subsequently that could cause the need for additional treatment facilities.

Water Quantity

Lack of knowledge about the geometry and characteristics of the aquifer complicates groundwater remediation. Without this information it is not possible to develop a water budget for the remediation.

Costs of Treatment

Cost questions can impede groundwater remediation. Who will pay, who are the responsible parties, and what is the appropriate share for each responsible party?

Recommendations to Help Groundwater Remediation

The following recommendations for state action can help protect groundwater quality and remediate when necessary to maintain California's water resources:

1. Provide additional funding where appropriate to help local agencies and governments develop remediation projects.
2. Quickly identify the agencies or entities that caused the contamination, so that they can provide funding to build treatment facilities and operate and maintain them.
3. Provide technical assistance for development of remediation projects.
4. The state (SWRCB, RWQCBs, DTSC, DWR) should compile information on currently operating remediation projects, including:
    - Contaminant(s) involved
    - Amount of contaminant(s) in the aquifer that must be removed, which will require many more monitoring wells
    - Type of treatment
    - Expected length of operation of the treatment project, which is directly dependent on the data collected
    - Capital cost of the project
    - Annual operating and maintenance cost, including costs of waste disposal
    - Amount of groundwater treated per unit time
    - Seasonality of volume treated (the amount may vary seasonally depending on usage)
    - Number of wells extracting groundwater
    - Number of connections served
    - Measures that could have prevented the contamination
5. Provide local governments and local agencies with state assistance to implement source water protection measures based on the source water assessments that were completed as of 2003 to protect recharge areas from contamination, so that groundwater remediation will not be necessary in the future.
6. Provide state assistance to local agencies to prevent contamination of recharge areas.
7. The state should develop techniques to inventory, model and evaluate feasible actions to improve the long-term availability of groundwater and the long-term quality of groundwater as a vital component of California's water resources for beneficial uses.
8. Local government and local agencies should limit potentially contaminating activities in areas where recharge takes place and work together to develop a sustainable good quality long-term water supply for beneficial uses.

Information Sources

- Belitz, Kenneth; Dubrovsky, Neil M.; Burow, Karen; Jurgens, Bryant; and Johnson, Tyler, 2003, *Framework for a Ground-Water Quality Monitoring and Assessment Program for California,* U.S. Geological Survey Water-Resources Investigations Report 03-4166 at the following URL: http://water.usgs.gov/pubs/wri/wri034166/
- California Department of Health Services, *Drinking Water: Chemical Contaminants in Drinking Water,* available at the following URL: http://www.dhs.ca.gov/ps/ddwem/chemicals/chemindex.htm
  California Department of Health Services, *Drinking Water: Overview of Monitoring Results 1994-2002, and an Indication of Dominant Contaminants,* available at the following URL: www.dhs.ca.gov/ps/ddwem/chemicals/monitoring/results94-02.htm
  California Department of Health Services, *Drinking Water Source Assessment and Protection Program (DWSAP),* available at www.dhs.ca.gov/ps/ddwem/dwsap/DWSAPindex.htm
- California State Water Resources Control Board, Division of Clean Water Programs at www.swrcb.ca.gov/gama/
- Focazio, Michael J.; Reilly, Thomas E.; Rupert, Michael G.; Helsel, Dennis R., 2002, *Assessing Ground-Water Vulnerability to Contamination: Providing Scientifically Defensible Information for Decision Makers*, U.S. Geological Survey Circular 1224.
- Freeze, R. Allan; Cherry, John A., 1979, *Groundwater*, Prentice Hall, 604 p.
- Information about chemicals: www.cdc.gov/niosh/npg/npg.html

Matching Water Quality to Its Use

Matching water quality to its use is a management strategy that recognizes that not all water uses require the same quality water. One common measure of water quality is its suitability for an intended use, and a water quality constituent is often only considered a contaminant when that constituent adversely affects the intended use of the water. High quality water sources can be used for drinking and industrial purposes that benefit from higher quality water, and lesser quality water can be desirable for some uses, such as riparian streams with plant materials benefiting fish. Further, some new water supplies, such as recycled water, can be treated to a wide range of purities that can be matched to different uses. The use of other water sources, again, like recycled water, can serve as a new source of water that substitutes for uses not requiring potable water quality.

Current Status of Water Quality Matching in California

SWRCB has identified 23 beneficial use categories of water, for mostly human and in-stream uses. Human uses can be categorized as consumptive, such as municipal, agricultural, and industrial supplies, and non-consumptive, such as navigation, hydropower generation, and recreation. Matching water quality to most of these uses is important because, except for municipal and industrial uses, water is generally used as-is, without treatment.

Farmers currently match crops to the available water quality. In general, irrigation water should contain levels of constituents such as salinity and boron that will not inhibit the yields of some crops. Conversely, agricultural water supplies that have low levels of salts may require adding gypsum to improve percolation. Agricultural water supplies that are turbid may require sand filtration to remove particulate matter that could clog drip irrigation systems. Imperial Irrigation District uses siltation basins to clarify Colorado River water before it can be used for irrigation.

Alternatively, ambient, in-stream water must be suitable to support a wide range of aquatic habitats and conditions. Thus, water quality for in-stream uses generally must be free of a variety of contaminants, not just a few. One particular pollutant that greatly affects fisheries is temperature. An example of an effort made to match water quality to an environmental use for that particular pollutant is the Temperature Control Device at Shasta Dam, which was built to better match water temperature to the reproductive needs of salmonid fish downstream.

For drinking water supplies, it is important to start with the highest quality source water possible. Historically, California’s urban coastal communities, Los Angeles, San Francisco, Oakland and Berkeley, constructed major aqueducts to such sources as Hetch Hetchy, Owens Valley, and the Mokelumne River. Later, water supplies of lesser quality, such as the Sacramento-San Joaquin Delta and the Colorado River, were also tapped for domestic water supplies. In response, many utilities already manage water quality by blending higher quality water supplies with those of lower quality, as well as matching treatment process to source water quality, as required by regulation. For example, Metropolitan Water District of Southern California dilutes high salinity Colorado River water with lower salinity water from the Bay-Delta — which in turn dilutes the higher organic carbon levels in Delta water with Colorado River water containing lower levels of organic carbon. In Solano County, higher quality, less variable Lake Berryessa water is blended with lower quality, highly variable North Bay Aqueduct water from the Delta. Likewise, many water suppliers have the capability to blend groundwater, local surface water, and imported supplies to achieve a desired water quality, although some utilities may instead choose to use water supplies based upon cost minimization or water rights considerations. Some water agencies even blend water (and water quality) from different levels of the same reservoir, by using different intake levels. Many water management actions, such as conjunctive use, water banking, water use efficiency, and water transfers, intentionally or unintentionally, result in one type of water quality traded for, or blended with, another.

Business also matches water quality to use. Water used in high-technology applications is often purer than that used for drinking. For instance, Silicon Valley manufacturers and other businesses in the San Francisco Bay Area prefer higher quality Hetch Hetchy water to Delta or groundwater supplies that are also available in the region. For other uses, lower quality waters can be used. Cooling water used in production is often of a lower quality than that used for drinking. The Central and West Basin Municipal Water Districts offer different qualities of recycled water -- at different costs--tailored to different uses, including process water for petroleum refining. At least one concrete plant in San Francisco captures and reuses its low quality stormwater runoff for concrete production.

CALFED has proposed two water quality exchange projects, the San Joaquin Valley-Southern California Water Quality Exchange Program, and the Bay Area Water Quality and Supply Reliability Program, to improve water quality and water supply reliability--as well as disaster preparedness--on a regional basis. These programs could promote matching water quality to its use, with potentially no degradation to the ultimate use of the water. For instance, in the Bay Area, a local water agency with access to a water supply of relatively lower water quality, could fund water recycling or water conservation projects in another agency's service area that has a higher quality water supply, in exchange for the higher quality water saved by those projects. Under the San Joaquin Valley-Southern California Water Quality Exchange Program, Metropolitan is working with both the Friant Water Users Authority and the Kings River Water Association to investigate the feasibility of exchanging water supplies. Metropolitan is interested in these exchanges to secure higher quality Sierra water supplies that could result in treatment cost savings and an increased ability to meet more stringent drinking water quality regulations. In return for participating in the water quality exchange, Friant and Kings are interested in securing infrastructure improvements, financed by Metropolitan, which will increase water supply reliability for their members.

Potential Benefits

For agricultural and in-stream uses, water quality matching is an integral part of water quality management, because there is generally no treatment of these water supplies prior to their use. For drinking water, appropriately matching high quality source waters can reduce the levels of pollutants and pollutant precursors that cause health concerns in drinking water. In addition, less costly treatment options can be used when water utilities start with higher quality source waters, and water supply reliability can simultaneously be enhanced.

For municipal and industrial customers, using water high in salinity can cause economic costs through damages to plumbing and fixtures and water-using devices and equipment. One study, conducted in 1998 by the U.S. Department of the Interior and the Metropolitan Water District of Southern California, found that for every 100 mg/L decrease in salinity, there is an economic benefit of $95 million annually to Metropolitan's customers.

Improved treated water quality and water supply reliability are also potential benefits of water quality matching for those agencies that have access to a diverse water supply portfolio. One example is the Santa Clara Valley Water District, its retail agencies, and other water suppliers along the South Bay Aqueduct, which have access to Delta water, Hetch Hetchy, local surface water, and groundwater. During droughts, seawater intrusion increases the level of salinity in Delta water supplies, including bromide. In such an event, agencies and regions with water source flexibility could use more groundwater or local surface water, if available, both of which are relatively bromide-free and thus do not create bromate, a potential carcinogen, upon disinfection with ozone.

Potential Costs

Water that contains lower levels of salinity is a better match for domestic water quality uses and for irrigating salt-intolerant crops such as strawberries and avocados. As noted, some agencies blend water supplies to achieve a desired water quality, including salinity. However, should low salinity water supplies be unavailable, water utilities may instead have to treat high salinity water supplies to achieve a desired water quality. In the Chino Basin, utilities already demineralize (desalt) water for domestic use, and Zone 7 Water Agency and Alameda County Water District have similar plans. At ACWD, for example, the capital costs alone of its new groundwater desalting project in Newark were $1.3 million per acre-foot per day of capacity, with operations and maintenance costs of $500 per acre-foot. In some cases, costs for matching water quality to use will also include new conveyance systems to connect different source waters.

The primary costs of water quality exchanges are: infrastructure, conveyance (such as energy, capacity, and hydraulic losses), and incentive payments for participants (i.e., the incentive driving the Friant/Kings-Metropolitan programs is Metropolitan's willingness to invest in local infrastructure that will benefit the exchange partner). In 2003, however, a "no-cost" water quality exchange was implemented between the Environmental Water Account, Kern Water Bank, and Metropolitan. Under the exchange, EWA had purchased groundwater in Kern Water Bank and was seeking to avoid a storage fee for leaving the purchased water in the bank. Metropolitan offered to receive EWA's purchased water in exchange for providing the EWA with a surface water supply later in the year when EWA could use the water. Metropolitan benefited from the exchange because it received groundwater supplies with low total organic carbon and bromide levels during a period when Metropolitan was unable to blend total organic carbon levels down with Colorado River supplies. Other "no cost" exchanges are being explored that are similar to this arrangement. One example is for an urban water user to provide agricultural water users with surface supplies during the peak agricultural water demand period, when agricultural users are forced to use groundwater and may be facing pumping constraints. In return, the agricultural user would return a like amount of pumped groundwater during the fall-winter period when there is excess groundwater pumping capacity and bromide and total dissolved solids in Bay-Delta supplies are higher. In addition to water supply benefits, use of Delta water in groundwater recharge and banking operations may also provide water quality benefits as well by substantially reducing levels of turbidity, pathogens, and organic carbon upon withdrawal.

Major Issues

Many of the issues of matching water quality to use are integrally connected to pollution prevention.

Water Transfers

Water quality exchanges face similar regulatory, institutional, and third-party impact issues that water supply transfers face (please see the Water Transfers narrative for a discussion of those issues). In particular, water supplies are generally governed by place-of-use restrictions that must be addressed when exchanging water supplies. Moreover, water quality exchanges could have adverse third-party impacts, such as increasing the salinity of local groundwater, reducing the availiability of higher quality in-stream water needed for fisheries, and limiting agriculture to salt-tolerant crops. For drinking water, an exchange could also trade bromide and organic carbon, precursors to contaminants with probable risks, for arsenic, one of the few known carcinogens regulated in drinking water.

Unusable Water

There is often a high cost incurred by water supplies that become either unsuitable for certain uses, or very expensive to use, because of contamination. One specific example, cited in a recent study by the Environment California Research and Policy Center, is the contamination by methyl tertiary-butyl ether (MTBE, a gasoline additive that may cause cancer) which initially closed 80 percent of Santa Monica’s drinking water wells, in turn forcing that city to increase its dependence on imported water sources, and later to install treatment to reduce MTBE levels. More generally, nitrate has closed more public water supply wells in California than any other contaminant, often permanently redirecting the use of such contaminated water to irrigation.[1]

Salinity

Agricultural drainage, imported Colorado River water, and seawater intrusion in the Delta and coastal aquifers all contribute to increasing salinity in all types of water supplies, which can adversely affect many beneficial uses, including irrigation, fish and wildlife, and domestic use. The primary tool to reducing salinity impacts is matching water quality to its use, because many sources of salinity, such as seawater intrusion, are natural, and treatment to remove salinity is relatively expensive. Further, water supplies that are high in salinity increase the cost of recycling or recharging these supplies in aquifers for subsequent re-use.

Operations Criteria for Storage and Conveyance

Water quality currently plays a relatively minor role in the operation of most local, state, and federal water projects. Most reservoirs and other projects, such as water transfers and the Environmental Water Account, are operated to achieve goals and objectives related to water supply, power production, flood control, fish and wildlife protection, and even recreation—but not water quality. In the Delta, the only water quality standards for project operations are for salinity, to protect agricultural, in-stream, and municipal and industrial uses. However, these ambient water quality standards do not reflect water user demand for lower salinity water supplies. Moreover, other parameters of concern for domestic uses, such as pathogens and organic carbon, do not have operating criteria and, further, do not have objectives in basin plans or discharge requirements in NPDES permits.

Upstream and Downstream Partnerships

Presently, few partnerships exist between upstream source water areas, downstream water users, and the water users in between that affect water quality, resulting in a critical disconnect in the overall system. Such partnerships could lead to pollution prevention or trading opportunities that could result in more efficient water quality protection.

Ecosystem Restoration and Drinking Water Supplies

Some ecosystem restoration projects, such as wetlands restoration, may improve habitat and even some aspects of water quality, but at the same time, may degrade other aspects of water quality, such as

[1] For a fuller discussion, please see the Aquifer Remediation narrative.

mercury or organic carbon (from a drinking water perspective). The CALFED Bay-Delta Program is actively investigating this potential conflict in matching water quality to its use (see ecosystem restoration strategy).

Recommendations to Improve Water Quality Matching

1. The state, local water agencies, and regional planning efforts should manage water supplies to optimize and match water quality to intended uses and available and appropriate treatment technology.
2. Consistent with the watershed-based source-to-tap strategy recommended in the pollution prevention narrative, the state should help facilitate system-wide partnerships between upstream watershed communities and downstream users along the flow path, in order to seek ways to better match water quality to its use; one such example is the Sacramento River Watershed Program.[2]
3. The state should facilitate and streamline water quality exchanges that are tailored to better match water quality to use, while mitigating any adverse third-party impacts of such transfers, as well as ensure that place-of-use issues are addressed in a manner that protects an exchange participant's water rights.
4. The state and local agencies should better incorporate water quality into reservoir, Delta, and local water supply operations, as well as facility re-operation and construction. For example, the timing of diversions from the Delta, and thereby the concentrations of salinity and organic carbon in those waters, could be better matched to domestic, agricultural, and environmental uses. Alternatively, the timing and location of urban and agricultural discharges to water sources, including the Delta, could also be coordinated with the eventual use of water conveyed by potentially impacted diversions. Facilities conveying municipal and industrial water could also be separated from those conveying water for irrigation.
5. To facilitate water re-use downstream, the state should encourage upstream users to minimize the impacts of non-point urban and agricultural discharges through BMP implementation, and treat wastewater to the highest level possible.

Sources of Information

- *Down the Drain*, Environment California Research and Policy Center
- Water Quality Program Plan, CALFED Bay Delta Program, July 2000
- *Addressing the Need to Protect California's Watersheds: Working with Local Partnerships*, The Resources Agency and State Water Resources Control Board, April 2002
- *Salinity Management Study*, US Department of the Interior and Metropolitan Water District of Southern California, June 1998
- Sacramento River Watershed Program
- Alameda County Water District

[2] More information on this watershed-based approach can be found in the Pollution Prevention and Watershed Management narratives.

Other Resource Management Strategies

This section highlights a variety of water management strategies that have the potential to generate benefits that meet one or more water resource management objective, such as water supply augmentation, water quality enhancements. The overall message of this narrative is that there are potential water management strategies that have not been fully explored and may warrant further study. There are several reasons these strategies are not more fully developed. Some of these reasons are:

- Needs more research, trials or evidence
- Currently costs exceed the current ability or willingness of users to pay
- Emerging technologies
- Currently have a limited potential to produce water management benefits

A list of the strategies considered in this narrative is as follows1:

- Dewvaporation
- Fog Collection
- Rainfed Agriculture
- Transoceanic Water Bags

Dewvaporation (Atmospheric Pressure Desalination)

Dewvaporation is a specific process of humidification-dehumidification desalination. Brackish water is evaporated by heated air, which deposits fresh water as dew on the opposite side of a heat transfer wall. The energy needed for evaporation is supplied by the energy released from dew formation. Heat sources can be combustible fuel, solar or waste heat. The tower unit is built of thin water wetable plastic films to avoid corrosion effects and to minimize equipment costs. Towers are relatively inexpensive since they operate at atmospheric pressure.

Current Dewvaporation in California

Dewvaporation is still a developmental technology. Final demonstration project towers have been built and operated at ASU laboratories.
The Salt River Project and the ASU Office of Technology Collaborations and Licensing are currently sponsoring the Dewvaporation pilot plant program as an extension of grass roots support by the U.S. Bureau of Reclamation.

Potential Benefits from Dewvaporation

Dewevaporation can provide small amounts of water in remote locations. The basic laboratory test unit produces to 150 gallons/day. Eight of these units form a 1,000 gallon/day demonstration pilot plant of the Dewevaporation process.

Areas such as Yuma, Arizona and the desert regions of California could reclaim salt water at relatively low cost by taking advantage of their dry year-round climates.

[1] Note that the quantity and specificity of information varies between strategies. This is solely due to the amount of information available to staff and does not make any inferences as to the relative efficacy of the strategies.

Potential Costs of Dewvaporation

The capital cost of 1,000 gallon/day desalination plant can range between $1,100 and $2,000. Operating costs range from $0.80 to $3.70 per 1,000 gallons distillate, or about $260 to $1,200 per acre-foot, depending on fuel source, humidity levels and plant size.

Major Issues Facing Dewvaporation

1. Cost and affordability
2. Small Scale
3. Concentrate disposal

Information Sources

- Beckman, James. R., Arizona State University, Tempe, Arizona, and U.S. Bureau of Reclamation. "Carrier Gas Enhanced Atmospheric Pressure Desalination." Final Report. October 2002.

Fog Collection

Precipitation enhancement also includes other methods, such physical structures or nets used in fog collection, to induce and collect precipitation.

Current Fog Collection in California

Precipitation enhancement in the form of fog collection has not been used in California as a management technique but does occur naturally with coastal vegetation; fog provides an important portion of summer moisture to our coastal redwoods.

Potential Benefits of Fog Collection

There has been some interest in fog collection for domestic water supply in some of the dry areas of the world near the ocean where fog is frequent. Some experimental projects have been built in Chile, and there has been consideration of such in some parts of the Middle East and South Africa. The El Tofo, Chile project yielded about 10,600 liters per day from about 3500 square meters of collection net, about 3 liters per day per square meter of net. Due to its relatively small production, fog collection is currently limited to producing domestic water where little other viable water sources exist.

Potential Costs of Fog Collection

The lowest costs for fog collection in Chile, where labor is much less expensive than California, were about $1.40 per 1,000 liters, or about $ 1,750 per acre-foot.

Information Sources

- Proceedings of the Second International Conference on Fog and Fog Collection, P.O. Box 81541 Toronto, Ontario, Canada, July 2001.

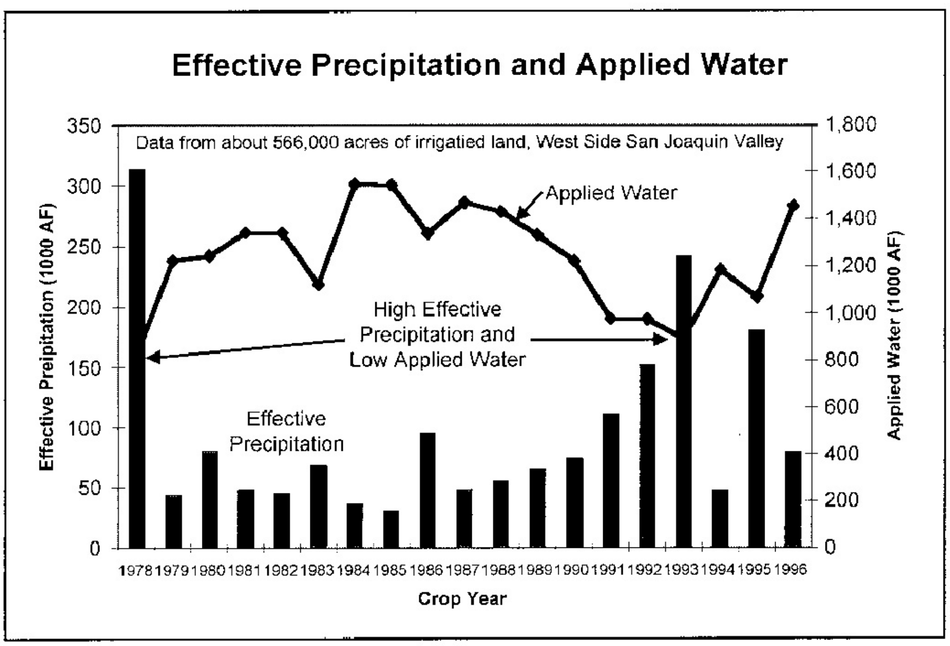
Rainfed Agriculture

Rainfed agriculture is when all crop consumptive water use is provided directly by rainfall on a real time basis. Due to unpredictability of rainfall frequency, duration, and amount, there is significant uncertainty and risk in relying solely on rainfed agriculture. This is especially true in California, where there is little or no precipitation during most of the spring and summer growing season.

Current Extent of Rainfed Agriculture in California

Climatic conditions in California provide excellent conditions for crop production; little cloud cover provides ample solar radiation during the spring and summer growing season. Precipitation in the form of rainfall and snow occurs mainly during the fall and winter months. However, the lack of sufficient and timely rainfall during the spring and summer in much of California severely limits the potential for expansion of rainfed agriculture.

In California's interior, north coast, and central coast, winter crops directly use rain water with the help of more irrigation water during the latter part of the winter season, if needed. These areas provide a relatively high return from the high value winter crops such as vegetables in the Costal areas. Other important agricultural production sectors that are dependent on rainfall are pastoral areas, rangelands, and rolling hills in the state. These areas produce significant amounts of feed and provide grazing areas for the state's large cattle (dairy and meet) industry. Winter small grains crops, such as winter wheat, account for about 4 percent (400,000 acres) of agricultural lands and provide a relatively small contribution to the state's total agricultural economy.



The vast majority of California's agricultural production requires irrigation. Rainfall that occurs before irrigation season and during the irrigation season can reduce irrigation water requirements. During years with heavy springtime rains, soil moisture remains higher for longer periods of time and can measurably reduce irrigation requirements for the year. Growers and water districts factor effective rainfall into their water management practices. In addition, DWR's water balance calculations for each region account for the portion of crop water requirements provided directly by rainfall.

As demonstrated in the figure on the previous page, applied water and rainfall events are closely related. More rainfall, particularly during early growing season, provides a significant quantity of effective rainfall for crop consumptive use. The figure shows the inverse relationships between effective rainfall and applied water. Based on the 18 years (1978-1996) of data for an area on the west side San Joaquin Valley, effective rainfall provided an average of 7 percent of the total crop consumptive use. In 1978 and 1993, two wet years with early season rainfall, effective rainfall amounted to 27 and 21 percent respectively of the crop consumptive use. In 1990, a dry year, effective rainfall amounted to only 3 percent of the total crop consumptive use. Similar examples can be given for other regions of the state.

Potential Benefits

Currently, improvements in the rainfed agricultural production offer limited water supply opportunity in California. More acreage for production of winter crops will reduce runoff flowing in the surface water systems and to ocean outflows. Improvements in rangelands and grazing areas through improved plant varieties can provide crop yield benefits but not significant water supply opportunities. One important aspect of improved rainfed agriculture is a better post harvest/ pre-planting soil management for winter crops such as wheat. Many winter wheat growers are already implementing adequate and prudent soil management practices for water and erosion management. Land that is tilled after harvest and left fallow in the fall and winter can cause the soil surface to seal with the first and second rainfall and increase runoff and erosion. Improved tillage practices, no-till or minimum-till, may improve water infiltration into soil root zone, thus increasing soil-water storage and could contribute to water supply by eliminating the first seasonal irrigation. Additionally, increased soil moisture reduces soil erosion; helps improve water quality and may help increase water use efficiency and economic efficiency. Advances in plant genetics to provide higher crop yields from direct rainfall could replace some crops that rely on irrigation.

Quantification of potential water savings from improved rainfed agriculture, while very small, is not possible due to lack of information.

Potential Costs

Potential cost consists of on-farm soil management and cost of research and development, demonstration and educational and training and dissemination of information and technologies. On-farm cost is an integral part of soil management that is already part of grower’s practices. Soil management practices may need to be adjusted for timing with no additional or minimal cost. Cost of research, development, demonstration, education, and training and dissemination of new information and tillage management technologies will need to be paid by the state. It is possible that such activities can be funded from CALFED Water Use Efficiency loans and grants.

Major Issues for Additional Rainfed Agriculture

While rainfed agriculture provides some opportunity for increasing yield and water supply reliability, the efforts will likely result in insignificant and unquantifiable contributions to the water supply. However, increases in yields for winter crops and winter cover crops can be significant and benefit overall water management in California. Water supply Improvements would require development of new varieties of plants, new and innovative soil and water management. A major issue is that quantification of water savings can not be made at the present time. Also, this strategy does not provide water supply benefits on a real time basis. For example, improvements in soil management may provide future benefit in storing more rainfall in the root zone if future uncertain and unpredictable weather conditions prevail.

Recommendations to Increase Rainfed Agriculture

Following is a list of recommendations to increase water use efficiency in the rainfed agriculture:

1. Develop improved varieties of winter rainfed crops, such as wheat, other small grains, cover crops, and winter crops. This can be achieved by providing financial resources to the state's research and development institutions to develop new and improved varieties. In addition, develop research and demonstration of innovative water management practices where growers with marginal lands and marginal production may shift from irrigated agricultures to rainfed winter crops.
2. Provide technical and financial assistance to promote no-till or minimum-till practices by growers who prepare their lands for planting during spring, but leave it fallow during the fall and winter. Cooperative efforts with the state's research and development institutions can benefit this important aspect of rainfed agriculture.
3. Develop new and innovative technologies, management, and efficient water management practices for rainfed agriculture, particularly winter wheat.
4. Provide technical and financial assistance to implement technologies, and management practices for rainfed agriculture.
5. Develop and promote new and innovative activities and management practices for intensive and managed grazing.
6. Maximize, collect, and store runoff from rainfed agriculture and develop cooperative efforts to link runoff from rainfed agriculture and water banking and conjunctive use activities and groundwater recharge.
7. Disseminate practical information through educational and training opportunities.

Information Sources

- Local agencies (reports and publications)
- Local farm advisors and UC System
- Federal Bureau of Land Management and National Forest Service
- Private rangeland owners and relevant associations of rangeland managers/owners
- United States Department of Agriculture, ARS
- State educational institutions (Fresno CIT, Cal Poly, etc.)
- Published technical and scientific papers
- California Cattlemen Association
- Commodity groups
- Ranches
- Information from best professional/scientific assessment/judgment of DWR's staff and others

Transoceanic Water Bags

The use of transoceanic water bags involves diverting water in areas that have unallocated fresh water supplies, storing the water in large inflatable bladders, and towing to an alternate coastal region. Fresh water is lighter than seawater, which makes the bags float on the surface. This makes them easier to tow. After discharging their contents, empty bags are then reeled to the deck of the tug allowing for a more speedy return to the source water area. Towing icebergs (frozen fresh water) is a variation of towing water bags.

Current Transoceanic Water Bag Use in California

Although this strategy is not currently being used in California, there have been several proposals to implement this technology throughout the world. The most recent is the proposal by Alaska Water Exports Company to divert up to 30 TAF from the Albion and Gualala River Rivers in Northern California and transport the water to the San Diego metropolitan area.

Potential Benefits of Transoceanic Water Bags

Freshwater supply augmentation

Potential Costs of Transoceanic Water Bags

Cost is contingent upon several factors such as water purchase cost, facility costs for diverting and off-loading water, environmental mitigation, administrative costs, cost to construct bags and towing costs. No published cost estimates have been found as of release of this draft.

Issues

Third-Party Impacts

Similar to any other type of transfer, impacts on the area of origin may occur. This includes projects that use "surplus" water and using water that is currently being put to a beneficial use. Other issues of concern expressed to proponents of recent projects include aesthetics and noise pollution from diversion facilities and the dissatisfaction within area of origin communities that others are exporting a local resource.

Environmental Impacts

Although most diversions take place near the mouth of a source river, facilities would need to be built to convey the water from a significant distance upstream (e.g. before blending with high salinity ocean water).

Pollution Prevention

Pollution prevention can improve water quality for all beneficial uses by protecting water at its source, reducing the need and cost for other water management and treatment options. By preventing pollution throughout a watershed, water supplies can be used, and re-used, for a broader number and types of downstream water uses. Improving water quality by protecting source water is consistent with a watershed management approach to water resources problems. In addition, the legal doctrine of "public trust" demands that the State protect certain natural resources for the benefit of the public, including uses such as fishing, protection of fish and wildlife, and commerce, all of which are affected by pollution.

Current Status of Pollution Prevention in California

There are many tools — regulatory, voluntary, or incentive-based — currently available for preventing pollution. The U.S. Environmental Protection Agency, State Water Resources Control Board, and Regional Water Quality Control Boards have permitting, enforcement, remediation, monitoring, and watershed-based programs to prevent both point source (e.g. from pipes) and non-point source pollution. Preventing pollution from most point sources relies upon a combination of source control and treatment, while preventing non-point source pollution generally involves the use of best management practices (BMPs). The SWRCB and RWQCBs are currently implementing total maximum daily loads (or TMDLs), to control both point and non-point source pollution, in those water bodies that are not attaining their water quality standards. Nonpoint source (NPS) pollution is responsible for 76% of the impairments in California's waters. The SWRCB and RWQCBs are also focusing on water quality issues related to abandoned mines, the U.S.-Mexico border, and beach closures. USEPA and DHS have sanitary survey and source water assessment programs specifically for drinking water sources. Beyond these state and federal efforts, many local agencies, businesses, farmers, non-governmental organizations, and watershed-based groups are preventing pollution directly, on their own or through partnerships.[1]

Surface Water Quality

As approved by USEPA, the State's official evaluation of its surface water quality is the SWRCB's biennial water quality assessment and the Clean Water Act 303(d) List of Water Quality Limited Segments. In 2002, California listed 685 water bodies on the 303(d) list, which do not meet their established water quality objectives. In some cases, a water body is listed for more than one pollutant, and in total, there are currently 1883 pollutant-water body listings. About 13 percent of the total miles of California's rivers and streams, and about 15 percent of its lake acreage, are now listed as limited. Water bodies are most often listed as impaired for pathogens, nutrients, pesticides, metals, and other organic chemicals (e.g. PCBs, PAHs). The potential sources most often noted as the cause of impairments are unspecified nonpoint sources, source unknown, agriculture, urban runoff, and natural sources. As of 2002, fish consumption advisories, an indirect indicator of surface water quality, were posted for 18 percent of California's lakes, while less than 1 percent of the state's rivers were similarly posted.

Groundwater Quality

Although standards or objectives do not cover all water quality contaminants (for example, perchlorate), the majority of wells (62 percent) reviewed by DWR's Bulletin 118 (*California's Groundwater*), using data provided by DHS, met Title 22 maximum contaminant levels (MCLs) for the period 1994-2000.

[1] Please refer to Volume 1, Chapter 2, for a more detailed discussion of the legal and regulatory framework for protecting ambient water quality.

However, in each of the state's hydrological regions, a large percentage of public water supply wells (ranging from 24 percent to 49 percent) exceeded one or more MCLs, usually for inorganic chemicals or radioactivity.[2] As a result of man-made contamination from agricultural practices and septic tanks, nitrate, which presents a known, acute (i.e. short-term) health risk, has closed more public water wells statewide than any other contaminant. Other groundwater contaminants of concern, including arsenic and hexavalent chromium (or chromium-6), are chronic (i.e. long-term) health risks, such as cancer or reproductive and endocrine system dysfunction. Another common groundwater contaminant, salinity--while not a health risk--is a concern for water palatability as well as economics. A different indicator of groundwater quality, leaking underground fuel tanks, has steadily declined after peaking in 1995, due primarily to the success of regulatory action. In addition to underground storage tanks, older landfills and hazardous waste disposal sites are also common sources of groundwater contamination, and abandoned wells can provide a ready conduit for aquifer contamination.

Environmental Water Quality

Throughout California, water quality impairments threaten riparian and aquatic habitats, and in some cases are major impediments to ecosystem restoration. Urban, military, industrial, hydropower, mining, logging, agricultural, grazing, and recreational activities impact water quality. Depleted freshwater flows, due to upstream dams, diversions, and inter-basin transfers, also affect the quality of water downstream, and have public trust doctrine implications. Other water management actions and projects, such as conjunctive use, conveyance, transfers, and conservation, can also affect water quality, both positively and negatively. Many significant pollution problems today are the result of persistent "legacy" pollutants, such as mercury, extracted from the Coast Range and used to process gold in the Sierra mines in the 19th century, and industrial chemicals such as polychlorinated biphenyls (PCBs), used in electrical transformers. These pollutants also contaminate sediments, making ecosystem restoration efforts more difficult. Hydraulic mining, which ceased during the 19th century, still has an adverse impact on numerous Central Valley rivers as well as San Francisco Bay. Some environmental contaminants of concern, such as mercury and selenium, are persistent or bioaccumulative — that is, their concentration and toxicity magnifies in the food chain — and can be toxic to key food chain links, such as aquatic invertebrates, and negatively impact communities and tribes dependent upon subsistence fisheries.

Drinking Water Sources

Public water systems in California have about 15,000 groundwater and 1,000 surface water sources of drinking water. About 4,000, or a quarter, of these sources have at least one detection of a regulated contaminant, usually from man-made sources, at a level greater than its MCL. The data specifically show a steady increase in the number of wells that exceed MCLs for nitrate and arsenic; moreover, the MCL for arsenic, a naturally-occurring contaminant, will drop further in 2006, affecting another 900 drinking water sources. Uranium, a naturally occurring radionuclide, and the organic chemicals trichloroethylene (TCE, an industrial solvent), 1,2-dibromo-3-chloropropane (DBCP, a now-banned nematocide) and methyl tertiary-butyl ether (MTBE, a gasoline additive), also frequently pollute drinking water sources. In addition to the one for arsenic, California will soon promulgate new MCLs for perchlorate and hexavalent chromium.

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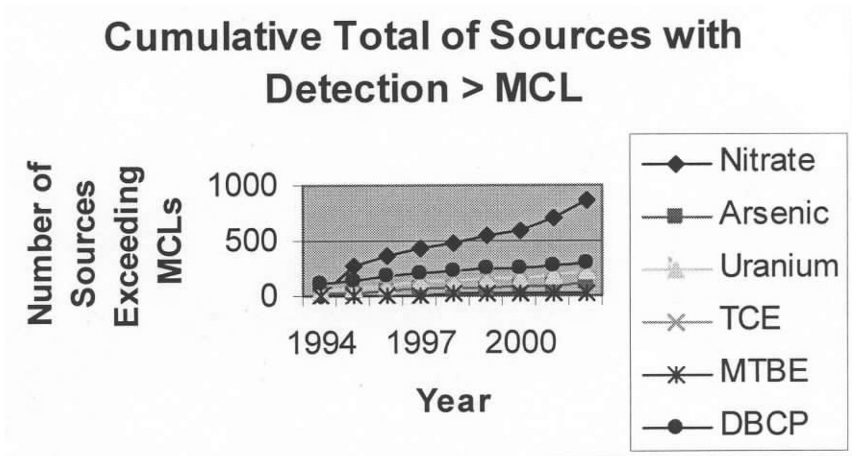
[2] The DHS database, though, only covered wells in about half of the groundwater basins in the state. And even for those basins that have wells in the database, the water quality in those wells is not necessarily representative of the water quality throughout the basin.

DHS, with the assistance of 34 counties and 500 water systems, recently completed source water assessments for 15,000 public drinking water sources in California. Initial evaluation of the assessment results indicates that groundwater sources (about 14,000 wells) are most vulnerable to septic tanks and sewage collection systems. Surface water sources are most vulnerable to surface water recreation and septic tanks. These assessments, combined with water quality monitoring, suggest that California is not doing enough to prevent nitrate pollution, an acute health hazard to infants and developing fetuses, the MCL for which has the lowest margin of safety of all regulated drinking water contaminants.



One particular water source, the Hetch Hetchy water supply (Tuolumne River) which serves over two million people in the San Francisco Bay Area, requires less treatment (i.e. no filtration) because of pollution prevention measures in its protected, Sierra watershed. More generally, forested watersheds play an important role in protecting water quality.

Another drinking water source, the Sacramento-San Joaquin Delta, provides some portion of the water supply for more than 22 million Californians. A unique aspect of this water source is that seawater introduces relatively high levels of bromide that, upon disinfection in a domestic water treatment plant, can contribute to the formation of disinfection by-products, such as trihalomethanes and bromate, which are potential carcinogens. Those water systems near the Delta that use it as a source of drinking water are also challenged by algal blooms as well as fluctuating levels of pH, turbidity, and alkalinity.

Potential Benefits

For the vast majority of contaminants, it is generally accepted that a pollution prevention approach to water quality is more cost-effective than end-of-the-pipe treatment of wastes, or advanced domestic water treatment for drinking water. Pollution prevention measures are usually more cost-effective because they have lower initial capital costs, as well as less ongoing operations and maintenance costs, than traditional engineered treatment systems. However, because of the nature and sources of some contaminants, like bromide (introduced by seawater) and organic carbon (natural runoff from the watershed), a pollution prevention approach may not be possible, cost-effective, or even desirable in some instances. Small water systems, which generally lack technical and financial capacities, may be more reliant upon pollution prevention measures than other options available to larger systems, such as advanced treatment.

Pollution prevention cannot only avoid economic costs, but also yield economic benefits. As one example, a 1998 Public Research Institute (cited in the 2002 SWRCB 305(b) report) study estimated that California beaches, which are often closed because of contamination from urban runoff, stormwater, and sanitary sewer overflows, contributed $73 billion to the U.S. economy, creating 883,000 jobs. Near-shore coastal waters provide multiple benefits or uses by also serving as a water source for desalination plants, as well as habitat for wildlife.

Potential Costs

According to the 2000 USEPA Clean Water Needs Survey, California has more than $14 billion of needs to prevent both point source and non-point source pollution. This survey, though, emphasized point source discharges, which represented more than $13 billion of the needs, and likely underestimated the cost of measures to adequately prevent non-point source pollution. In terms of drinking water quality, investments in pollution prevention measures may entail more risk and uncertainty in improving water quality relative to advanced domestic water treatment options.

Major Issues

Major issues facing pollution prevention include:

Urban Impacts

USEPA's most recent National Water Quality Inventory in 2001 found that pollution from urban and agricultural runoff are the primary sources of water pollution in the U.S. Urban runoff and stormwater wash pollutants, such as nutrients (lawn fertilizers and pet wastes), pesticides, oil and grease, metals, organic chemicals, microorganisms, and debris, from city streets and other hard surfaces, that impair surface waters (including beaches) and negatively impact existing and future groundwater replenishment projects that use stormwater for recharge (see urban runoff management, and recharge area protection strategies).

Agricultural Impacts

Agricultural drainage can impair water supplies with relatively high levels of salinity, nutrients, pesticides, sediment, and other contaminants, as can wastes from dairies and feedlots, which are high in nitrates and microbes. In the Central Valley, the Regional Water Quality Control Board has endorsed the use of farm-based watershed groups to monitor water quality and implement best management practices (BMPs) to control nonpoint source pollution from seven million acres of irrigated lands (i.e. crops, nurseries, and managed wetlands).

Natural Impacts

Relative to contamination introduced primarily by humans, organic carbon, derived from runoff from a watershed, and especially bromide, a component of ocean salinity, are largely a result of natural processes for which a pollution prevention approach may not be possible, effective, or appropriate. Further, organic carbon is beneficial to the ecosystem in general, and when combined with some advanced treatment options, both organic carbon and bromide can be less onerous in treated drinking water. While not ignoring pollution prevention opportunities, the use and integration of other water quality management tools, such as matching water quality to use and drinking water treatment and distribution, may be more effective and appropriate for these two contaminants. Arsenic, asbestos, radon, microbes from wildlife, dissolved minerals, and sometimes even sediment are other examples of naturally occurring contaminants for which a pollution prevention approach is infeasible.

Emerging Contaminants

Currently water agencies focus on pathogens (disease –causing microorganisms) and disinfectant by-products (potential cancer-causing contaminants), that are regulated or will be regulated in near future. Recently, though, unregulated chemicals found in pharmaceuticals and personal care products are emerging as water contaminants. For instance, as the state's population ages, there may be increasing levels of pharmaceutical discharges in domestic wastewater and to the environment. Such contaminants may not be removed by traditional treatment processes, and can negatively impact water recycling and groundwater recharge projects.

Population Growth Demands and Impacts

Future population growth and land-use changes may unpredictably affect water quality. As population and water demand increase, the volume of wastewater will also increase, which may then be discharged in proportions to the receiving water flow that could prevent some current domestic water sources to continue serving that beneficial use. Moreover, as demand for water grows, there may be demand as well to use some supplies--such as those originating from groundwater remediation sites--that would previously not have been approved for domestic use. For such supplies, drinking water standards alone may not be enough to determine quality, because such standards assume a basic purity of the water supply (see groundwater remediation/aquifer remediation). In addition, population growth may lead to increased demand for water-based recreation, which can degrade fisheries and wildlife habitat as well as drinking water supplies.

Monitoring and Assessment

Only a small portion of California water bodies are regularly monitored and assessed for water quality or even for the appropriate contaminants of concern. Once data is collected, it is too often not assessed or evaluated, and therefore not readily available for analysis. Much water quality data is collected on a project, rather than comprehensive, basis, and sampling program objectives, designs, methods, and quality assurance can vary greatly between projects. Even the SWRCB's biennial water quality assessment is limited by data availability, and notes as well another data dilemma: "healthy environments are less likely than troubled ones to be targeted for monitoring."

Fragmented Delivery and Regulation of Water Quality

Management and regulation of water quality in California is currently fragmented among at least eight state and federal agencies, with no one agency looking after water quality "from source to tap." For example, the state and regional boards regulate ambient water quality, while DHS primarily regulates treatment and distribution of potable water. Further, surface water in California is mostly managed by DWR and the U.S. Bureau of Reclamation, while groundwater is mostly not managed at all. Moreover, actually serving drinking water to Californians is an obligation of local agencies (cities and water districts) and private water companies that were generally not formed in any comprehensive pattern.

Legacy Pollutants

Although abandoned mines, clear-cut forests, and many former industrial and commercial sites leave behind pollution problems (e.g. leaking underground storage tanks), what is often not left behind is a legally responsible or financially viable party to fund clean up efforts. The state and federal governments and potentially responsible parties often wind up in extensive regulatory and legal proceedings determining legal and financial responsibility while hazardous waste sites remain to be remediated.

Pollutant-by-Pollutant Water Quality Management

Federal law requires that the state regulate water quality on a programmatic, pollutant-by-pollutant basis, even though our rivers, lakes, and bays — and the aquatic organisms in them — are actually exposed to a mix of pollutants. Much has yet to be understood about the combined effects of chemicals, temperature, pH, transport, sunlight, and other factors. From the standpoint of ecosystem integrity, it is important to recognize that major threats may not be observed in obvious fish kills, but instead may arise subtly through sub-lethal changes in reproductive rates, gene structure, nervous system functions, or immune response. Such changes can over time affect species survival, and population and ecosystem structure.

Recommendations to Improve Pollution Prevention

1. In addition to regulating water quality on a pollutant-by-pollutant basis, water quality problems should be best managed using a watershed-based "source-to-tap" approach. The state should adopt a preventative strategy that integrates improvements in pollution prevention, water quality matching, and, for drinking water, treatment and distribution. For pollution prevention, such a strategy would build upon urban and agricultural pollution prevention programs already initiated by the SWRCB and RWQCBs, as well as DHS's Source Water Assessment Program.[3] The strategy would focus in particular on the prevention of nitrate pollution statewide.
2. In order to help implement the previous recommendation, the state should adequately fund basin plan triennial review and updates, for incorporation into the *California Water Plan Update* (pursuant to Section 13141 of the California Water Code). Per the CALFED Record of Decision, the state should complete the drinking water policy for the Delta and its tributaries, which as an amendment to the basin plan for the Sacramento and San Joaquin Rivers Basins, will be an additional tool for drinking water source protection.
3. State agencies with a regulatory, management, or scientific role in the California's water quality should take the lead in establishing an Interagency Water Quality Program to coordinate and integrate all federal, state, and local water quality monitoring and assessment programs, for surface water and groundwater. This program would include a focus on emerging, unregulated contaminants in order to provide an early warning system of future water quality problems, as well as identify trends in water quality. Such a program would also seek to standardize methods, especially for monitoring of emerging, unregulated contaminants, regularly monitor the quality of all waters of the state, and provide compatible data management that is accessible to a wide range of users. For drinking water supplies, this monitoring program should include a focus on outcomes-based monitoring, such as biomonitoring and waterborne disease outbreak surveillance. [4]
4. Regional, tribal, and local governments and agencies should establish drinking water source and wellhead protection programs to shield drinking water sources and groundwater recharge areas from contamination. These source protection programs should then be incorporated into local land use plans and policies. Such programs would encourage or regulate land-use activities that are protective of water quality, or, alternatively, discourage or restrict land uses or activities that threaten surface and groundwater quality (see recharge area protection strategy.
5. The state should provide increased grant funding for source water protection activities.

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[3] Such a strategy would be much like the "Equivalent Level of Public Health Protection (ELPH)" process of the CALFED Drinking Water Quality Program, and similar efforts recently established by the Massachusetts Water Resources Authority (for Boston), New York City, and the national governments of Canada and Australia. This strategy would also conform to the recommendations of the 2000 International Conference on Freshwater, held in Bonn, Germany.

[4] The proposed Interagency Water Quality Program would be modeled after the existing Interagency Ecological Program. The groundwater portion of this effort should be consistent with the recommendations of AB 599 (the Groundwater Quality Monitoring Act of 2001) and DWR's Bulletin 118 (*California's Groundwater*), while the surface water aspects should be coordinated with SWRCB's Surface Water Ambient Monitoring Program (SWAMP, AB 982).

Information Sources

- *2002 California 305(b) Report on Water Quality*, State Water Resources Control Board, March 2003
- Bulletin 118, *California's Groundwater, Update 2003*, Department of Water Resources
- *A Comprehensive Groundwater Quality Monitoring Program for California* (AB 599 Report to the Governor and Legislature), State Water Resources Control Board, March 1, 2003
- National Water Quality Assessment Program, US Geological Survey
- State Water Resources Control Board/Regional Water Quality Control Boards, Strategic Plan, November 15, 2001
- State Water Resources Control Board/Regional Water Quality Control Boards, *Nonpoint Source Program and Implementation Plan, 1998-2013 (PROSIP)*, January 2000
- *Water Quality Program Plan*, CALFED Bay Delta Program, July 2000
- California Coastal Commission, www.coastal.ca.gov
- USEPA National Water Quality Inventory
- DHS data Web site: www.dhs.ca.gov/ps/ddwem/chemicals/chemindex.htm
- Interagency Coordinating Committee (for NPS Pollution Control)
- Environmental Protection Indictors for California (EPIC)

Precipitation Enhancement

Precipitation enhancement is when clouds are artificially stimulated by “cloud seeding” to produce more rainfall/snowfall than they would naturally. Cloud seeding injects special substances into the clouds that enable snowflakes and raindrops to form more easily. Precipitation enhancement is the one form of weather modification conducted in California; hail suppression and fog dispersal (when fog is below freezing temperature) projects are conducted in other states.

Current Precipitation Enhancement in California

The first serious cloud seeding program in California began in 1948 on Bishop Creek in the Owens River basin for California Electric Power Company. Precipitation enhancement in the form of cloud seeding has been practiced continuously in several California river basins since the early 1950s. Most projects are located along the central and southern Sierra Nevada with some in the coast ranges. The projects use silver iodide as the active cloud seeding agent, supplemented by dry ice if aerial seeding is done. The silver iodide can be applied from ground generators or from airplanes. Occasionally other agents, such as liquid propane, have been used. In recent years, some projects have also been applying hygroscopic materials (substances which take up water from the air) as supplemental seeding agents. The following figure shows rain and snow enhancement programs for the 2002 - 2003 season.

Operators engaged in cloud seeding have found it beneficial to seed rain bands along the coast and orographic clouds over the mountains. The number of operating projects has tended to increase during droughts, up to 20 in 1991, but have leveled off to about 12 or 13 in recent years. The total area covered by these projects is around 13,000 square miles.

Policy statements by both the American Meteorological Society and the World Meteorological Organization support the effectiveness of winter orographic cloud seeding projects. The American Society of Civil Engineers has also shown interest with its Policy Statement No. 275 on Atmospheric Water Management in 2003 and a new report, ASCE/EWRI 42-04, "Standard Practice for the Design and Operation of Precipitation Enhancement Projects" in May 2004. This standards document will be a sequel to ASCE Manual No. 81, "Guidelines for Cloud Seeding to Augment Precipitation", published in 1995.

Benefits from Precipitation Enhancement

In California, all precipitation enhancement projects are intended to increase water supply or hydroelectric power generation. The amounts of water produced are difficult to determine, but estimates range from a 2 to 15 percent increase in annual precipitation or runoff. A detailed study by the Utah Department of Natural Resources in 2000 showed an average increase in April 1 snowpack water content ranging from 7 to 20 percent from a group of projects which had been operating from 9 to 22 years. The overall estimated annual runoff increase was about 250,000 acre-feet, or 13 percent for the study area. Actual increases in annual runoff are probably significantly less in California than in Utah. One conservative estimate is that the combined California precipitation enhancement projects currently generate 300,000 to 400,000 acre-feet annually, which would be an average of about a 4 percent increase in runoff.

New NRC Report on Weather Modification

In the fall of 2003, the National Research Council released a report entitled "Critical Issues in Weather Modification Research", which examined the status of the science underlying weather modification in the U. S. One conclusion widely reported by the press was that convincing scientific proof of the efficacy of weather modification was lacking and the authors proposed that a large sustained research program be developed to reduce the uncertainties of this technology. The report does not have much material on winter orographic cloud seeding, such as practiced in California and other western states, but does seem to concur that there is much evidence that it does work, possibly up to a 10 percent increase. Progress in seeding agent formulation and targeting was noted, although there is need for more research on these aspects as well.

Another 300,000 to 400,000 acre-feet per year may be available. Many of the best prospects are in the Sacramento River basin, in catchments that are not seeded now. The Lahontan regions are already well covered by cloud seeding projects, except for the Susan River. With the exception of the upper Trinity River watershed, and perhaps the Russian River, there is little new potential in the North Coast region because not much extra rainfall could be captured due to limited storage capacity. There is also potential to increase water production by more effective seeding operations in existing projects.
Precipitation enhancement should not be viewed as a remedy for drought. Cloud seeding opportunities are generally less in dry years. It works better in combination with surface or ground water storage to increase average supplies. In the very wet years, when sponsors already have enough water, cloud seeding operations are usually suspended.

Potential Costs

Costs for cloud seeding generally would be less than $20 per acre-foot per year. State law says that water gained from cloud seeding is treated the same as natural supply in regard to water rights.

It is estimated that about $3 million are being spent on current operations. Realizing the additional 300,000 to 400,000 acre-feet of potential new supply could require around $7 million, which would be about $19 per acre-foot. An initial investment of an estimated $1.5 million to $2 million in planning and environmental studies would also be required.

Major Issues for Precipitation Enhancement

There are major issues facing the use of precipitation enhancement practices.

Reliable Data

No complete and rigorous comprehensive study has been made of all California precipitation enhancement projects. Part of the reason is the difficulty in locating unaffected control basins for the standard target and nearby control area comparisons since wind variations would cause spillover into adjoining basins. Some studies of individual projects have been made in the past years on certain projects, such as the Kings River, which have shown increases in water.

Operational Precision

It is difficult to target seeding materials to the right place in the clouds at the right time. There is an incomplete understanding of how effective operators are in their targeting practices. Chemical tracer experiments have been provided support for current targeting practices.

Concern over Potential Impacts

Questions about potential unintended impacts from precipitation enhancement have been raised and addressed over the years. Common concerns relate to downwind effects (enhancing precipitation in one area at the expense of those downwind), long term toxic effects of silver, and added snow removal costs in mountain counties. The U.S. Bureau of Reclamation did extensive studies on these issues. The findings are reported in its Project Skywater programmatic environmental statement in 1977 and in its Sierra Cooperative Pilot Project EIS in 1981. The available evidence does not show that seeding clouds with silver iodide causes a decrease in downwind precipitation; in fact, at times some of the increase of the target area may extend up to 100 miles downwind (Ref. 1981 SCPP EIS). The potential for eventual toxic effects of silver has not been shown to be a problem. Silver and silver compounds have a rather low order of both acute and chronic toxicity. According to the Bureau of Reclamation, the small amounts used in cloud seeding do not compare to industry emissions of 100 times as much into the atmosphere in many parts of the country or individual exposure from tooth fillings. Watershed concentrations would be extremely low because only small amounts of seeding agent are used. Accumulations in the soil, vegetation and surface runoff have not been large enough to measure above natural background. A recent study (2004) done for Snowy Hydro Limited in Australia has confirmed the earlier findings cited above. In regard to snow removal, little direct relationship to increased costs was found for small incremental changes in storm size because the amount of equipment and manpower to maintain the roadway is essentially unchanged. For example, the effort is practically the same to clear 5.5 inches compared to 5 inches of snow on the road.

All operating projects have suspension criteria designed to stop cloud seeding any time there is flood threat. Moreover, the type of storms which produce large floods are naturally quite efficient in processing moisture into rain anyway. In such conditions, seeding is unlikely to make much difference.

Concern About Continuance of Hydroelectric Utility Seeding Operations

Four of the existing cloud seeding projects in California are sponsored by hydroelectric utilities. These four projects probably account for about 1/3 of the estimated statewide water production by cloud seeding. There is some concern that if these power plant facilities are sold, either as part of deregulation or for other reasons, potential new owners may not be interested in continuing cloud seeding. This would result in some loss in water supply for downstream users who have been indirectly benefiting from the added water. The State Public Utilities Commission is aware of this possibility and has tried to ensure, as a condition of transfer, that weather modification would continue.

Funding

Little federal research funding for weather modification has been available in the last 15 years. The Bureau of Reclamation had some funding in 2002 and 2003 in the Weather Damage Mitigation program. Desert Research Institute of Nevada did obtain a grant of $ 318,000 from this source early in 2003 to evaluate its seeding in the eastern Sierra. The major portion of this research will be undertaken in the 2003-04 water year.

Recommendations to Increase Precipitation Enhancement

Following is a list of recommendations to increase precipitation enhancement:

1. Begin a new DWR program to investigate potential new cloud seeding projects. The State should support the continuation of current projects as well as the development of new projects and help in seeking research funds for both old and new projects.
2. DWR should collect base data and perform research on the effectiveness of California precipitation enhancement and how it could supplement other water supplies while minimizing negative impacts.
3. DWR should investigate the potential to augment Colorado River supply by cloud seeding, in cooperation with the Colorado River Board, the State of Arizona, the State of Nevada, and the U.S. Bureau of Reclamation.
4. DWR should keep abreast of current research on cloud physics and cloud modeling being done by the National Oceanic and Atmospheric Association (NOAA) labs and academic institutions. With improvement, these models may become tools to further verify and test the effectiveness of cloud seeding activities.
5. DWR should support efforts by California weather modification project sponsors, such as that proposed in 2002-03 by Santa Barbara County Water Agency, to obtain federal research funds for local research experiments built upon their operating cloud seeding projects.

Important Sources for Precipitation Enhancement

- ASCE Manual No. 81 “Guidelines for Cloud Seeding to Augment Precipitation” (1995)
- ASCE Policy Statement No. 275, “Atmospheric Water Resources Management, 2003
- ASCE/EWRI 42-04 “Standard Practice for the Design and Operation of Precipitation Enhancement Projects”, 2004.
- National Oceanic and Atmospheric Administration
- Desert Research Institute, Reno, Nevada
- American Meteorologic Society
- World Meteorological Organization
- USBR Project Skywater publications, various, 1975-1987, including those of
- the Sierra Cooperative Pilot Project in California.
- Sierra Cooperative Pilot Project, Environmental Assessment and Finding of
- no Significant Impact, USBR, Denver, 1981.
- NRC report “Critical Issues in Weather Modification Research”, The National Academies Press, Washington, DC, 2003.
- The Weather Modification Association’s Response to the NRC Report “Critical Issues in Weather Modification Research”, report of a review panel, Journal of Weather Modification, April, 2004.
- North American Interstate Weather Modification Council Response to NRC Report, April 2004, 2 pp, on www.naiwmc.org
- Snowy Hydro Limited, Cooma, NSW, Australia, “Assessment of the EnvironmentalToxicity of Silver Iodide and Indium Iodide, by Dr. Brian Williams, Adelaide University, 2004.

Recharge Areas Protection

Recharge areas protection includes keeping recharge areas from being paved over or otherwise developed and guarding the recharge areas so they don't become contaminated. Protection of recharge areas, whether natural or man-made, is necessary if the quantity and quality of groundwater in the aquifer are to be maintained. Existing and potential recharge areas must be protected so that they remain functional and they are not contaminated with chemical or microbial constituents. Zoning can play a major role in recharge areas protection by amending land-use practices so that existing recharge sites are retained as recharge areas. See the box on the following page for more discussion on recharge areas.

Current Recharge Areas in California

The first documented managed recharge program in California began in Los Angeles Basin in 1889. Beginning in the early 1900s, water agencies operated recharge areas in San Joaquin Valley. Water agencies established recharge areas along the east side of San Joaquin in the 1940s. Additional recharge areas were established later in southern California and San Francisco Bay area. While a certain amount of recharge takes place in many areas, the areas that were chosen by water management agencies were those areas that met 3 conditions. First, the sediment is coarse enough to allow surface water to infiltrate at a higher rate than other sediments. Second, there is hydraulic continuity between the recharge area, the aquifer in which the groundwater is stored and transported, and the discharge area where wells are built to extract the groundwater. Third, the local agency had access to the land on which these first 2 conditions existed.

Recharge Sites in California

Agency	Type of Recharge Site
Arvin-Edison WSD	Off-stream
Berrenda Mesa WD	Off-stream
Calleguas MWD	Injection wells
City of Bakersfield	In-stream, off-stream
Coachella Valley WD	In-stream, off-stream
Flintridge-Cañada WD	Injection well
Fresno County FC&WCD	Off-stream, injection wells
Friant-Kern Water Users Authority	In-stream
Kern Water Bank	Off-stream
Los Angeles County DPW	In-stream, off-stream, injection wells
Orange County WD	In-stream, off-stream, injection wells
San Bernardino County WC&FCD	Off-stream
Santa Ana Watershed Project Auth.	Off-stream, injection wells
Santa Clara Valley WD	In-stream, off-stream
United Water Conservation District	In-stream, off-stream

The size of existing recharge areas and the amount of groundwater that is recharged annually is substantial. The total amount of land devoted to spreading basins and off-stream and in-stream recharge probably exceeds 50 square miles. The actual area is difficult to determine, partially because many diversion ditches and creeks are active recharge sites during periods of the year. These active recharge areas and other areas should be protected for recharge purposes.

The Drinking Water Source Assessment Program (DWSAP) defines areas of protection for individual wells. The program can easily be expanded to include larger areas within the watershed. While the DWSAP requires assessment of these issues, the amendments to the Clean Water Act that require the assessment do not require implementation.

Recharge Areas

Recharge areas are those areas that provide the primary means of replenishing the groundwater that is stored in an aquifer. In simple terms, a groundwater system consists of three component parts—recharge areas, storage capacity called an aquifer, and discharge areas or points. If recharge areas cease functioning properly, there is no water to store in, or remove from, the aquifer. Under natural conditions sandy areas that lie over alluvial aquifers provide good recharge areas for that aquifer.

Natural recharge takes place without interference or assistance from people. Artificial, intentional, or managed recharge is additional recharge that takes place with the assistance of people. Artificial, intentional, or managed recharge can take place in areas where natural recharge occurs (stream channels or alluvial fans) by increasing flow volume and decreasing flow velocity. In addition, this recharge can take place in structures built specifically for increasing recharge. These structures are called recharge basins, spreading basins or replenishment basins or areas. The goal of all managed recharge is to increase the rate of infiltration or percolation of surface water into the subsurface, and ultimately, into the saturated zone in the aquifer. Some areas that would provide good rates of recharge have been paved over or built upon and are no longer available to recharge the aquifer.

The three types of recharge that are possible are in-stream, off-stream, and injection wells. In-stream recharge allows water to percolate through the stream bed itself. Off-stream recharge uses suitable sites outside the stream bed. In some operations, the water must be pumped some distance from its source to the off-stream recharge area. Injection wells are used at locations where the cost of large tracts of land would be prohibitive.

Each method has pros and cons. In-stream and off-stream spreading basins are eventually clogged with the suspended material carried in the surface water to the point that the rate of recharge declines considerably, making the basin much less effective. Those fines must somehow be removed. In urban areas the cost of land necessary for spreading basins may be prohibitive. Injection wells are expensive to build and are also subject to clogging unless the water is treated and turbidity is nil.

Protection of recharge areas consists of 2 components: (1) preventing the areas from being covered by urban infrastructure, which renders the land unusable for recharge; and, (2) preventing chemical or microbial contamination that would require expensive treatment before the water could be used for potable, agricultural, or industrial purposes.

TreePeople, a citizens' organization, has been working with local government to retrofit play grounds, school grounds, parking lots, and other parcels of land, to collect, treat, and funnel storm water to "dry" wells or other small scale infiltration facilities. Such wells are called Class V injection wells. To avoid contamination of the aquifer, certain best management practices are recommended. Those best management practices include low-flow basins for runoff from industrial areas and other areas that could provide a high level of chemical contamination, pre-treatment for runoff, monitoring of water quality, evaluation of the data, and corrective action as necessary. All counties are required to regulate any type of water-related well, including injection wells, but the effectiveness of that program are uncertain at best. Class V injection wells are further regulated for groundwater quality purposes by the U.S. Environmental Protection Agency in accordance with the Underground Injection Control program authorized by the Safe Drinking Water Act.

Benefits from Protection of Recharge Areas

The primary benefit of protecting recharge areas is assurance of a sustainable and reliable water supply of good quality. The availability of a sustainable and reliable water supply will eliminate the need to purchase alternative water supplies at greater expense.

Additional benefits of recharging groundwater include some microbial and chemical degradation while the water moves through the unsaturated zone to the saturated zone, an increase in the amount of groundwater in storage that can later be extracted for local use or for export, and in some cases, use of the aquifer itself as the conveyance system from the recharge area to the point of extraction and use.
In some cities, recharge basins are combined with flood control basins to reduce the amount of urban runoff.

Potential Costs

Some of the costs that may be associated with protecting recharge areas are:

- Purchase price of the land that is to be used for a recharge area.
- Design and construction of facilities.
- Land that is reserved for recharge areas can not be used for other purposes that might provide a significant income for the landowner and tax revenues for the government.
- If a local government agency owns the land, there is no tax income for the county.

By not protecting recharge areas, water supply can be lost. The growth of urban areas, with roads, freeways, parking lots, and large warehouse type buildings, means that many areas no longer allow runoff to infiltrate into the ground. Instead, the runoff flows rapidly into streams which peak more quickly and at higher flow rates than before the urban facilities were built. This runoff is lost to groundwater recharge and may require the expense of other facilities to provide a substitute for that lost recharge. In some urban areas, injection wells have been built to take the place of recharge that was lost to urban development. Injection wells are expensive and are not always successful, but they may be cost effective in the face of the high cost of urban land in many cities.

Many potentially contaminating activities have routinely been allowed in recharge areas and contaminants have been carried into the aquifers. Remediation of these areas can take decades, costs millions or billions of dollars, and will never remove the contaminant completely from the aquifer. In such cases, the extracted groundwater must be treated at the wellhead at significant expense before it is suitable for potable and other uses.

A lack of protection of recharge areas could decrease the availability of usable groundwater. Recent studies by the USGS show contaminants present in recharge areas for aquifers in the Los Angeles area. In 10, 20, or 40 years, those contaminants will have been transported into the aquifer and the groundwater may require treatment before it can be used, thereby increasing the cost of water to the users. Protection of recharge areas now will help to prevent costs from escalating astronomically in the future. Because of the low velocity of groundwater movement through the aquifer, contamination that occurs today may not arrive at down-gradient wells for 10 years or longer. If we protect recharge areas by retaining those areas for recharge and by preventing contamination today, we are reducing future costs.

Major Issues Relating to Protection of Recharge Areas

The major issues facing protection of recharge areas are:

Data and Standards

There is a lack of standardized guidelines for pre-treatment of the recharge water, including recycled water. There is also a lack of monitoring wells to provide data on changes in groundwater quality that may be caused by recharge. Inspection programs are generally not adequately funded and staffed to locate, inspect, design protection measures, and destroy abandoned wells that provide vertical conduits for contamination of aquifers.

Zoning

Local governments often lack a clear understanding of the location and function of recharge areas and how to protect those areas from development and/or contamination. This results in lack of appropriate land use zoning that recognizes the need for recharge area protection for water quantity and water quality.

Vector and Odor Issues

Standing water in recharge ponds or spreading basins is an attraction for mosquitoes (Diptera), dragonflies (Odonata), and other insects whose egg, larval, and pupal stages mature underwater. Dragonflies eat insects they catch on the fly, but mosquitoes can be vectors for a number of serious or deadly diseases. Existing recharge programs use large numbers of "mosquito" fish which feed on the mosquito larvae in the water. Odors can be generated by growth and decay of algae and other water-borne vegetation. Both vectors and odors must be addressed in any recharge program that involves standing water.

Potential Impacts

Protection of recharge areas will remove that land from the possibility of other uses.

Recommendations to Help Promote Protection of Recharge Areas

The State can help promote additional protection of recharge areas by acting on the following recommendations:

1. Increase state funding for proposals to identify and protect recharge areas including incentives for the location and proper destruction of abandoned water wells, monitoring wells, cathodic protection wells and other wells that could become vertical conduits for contamination of the aquifer. Provide funding and staff for Department of Health Services to initiate a program that would provide guidance and funding for local governments and agencies to implement source water protection measures that are logical outgrowths of the DWSAP.
2. Expand research into surface spreading as a means of groundwater recharge and the fate of chemicals and microbes contained in the recharge water.
3. Develop a statewide program to identify potential recharge areas throughout the state and provide that information to local land use agencies (city and county governments).
4. Amend state law to prohibit local decision-makers from developing land for other purposes until it is know if that land is needed for recharge as a part of the local agency's groundwater management program.
5. Engage the public in an active dialogue using a value-based decision-making model in planning land use decisions that involve recharge areas. Adopt a state-sponsored media campaign to increase public awareness and knowledge of groundwater and the importance of recharge areas.
6. Establish a "Water" element in the General Plan process that specifically requires a discussion by local government of the cost and values of protecting recharge areas versus the cost of non-protection. Eminent domain should not be allowed to convert potential recharge areas to other uses.
7. Ensure that federal and state programs regulating subsurface disposal in accordance with the Safe Drinking Water Act's Underground Injection Control program and the California Clean Water Act's waste discharge requirements are fully funded and staffed.

8. Require local governments to provide protection of recharge areas for aquifers that have been identified as “sole source aquifers” pursuant to the Safe Drinking Water Act of 1974 (P.L. 93-523) and Amendments.
9. Develop educational programs for public works officials and other officials of local agencies and governments that will allow them to develop programs that realistically deal with the interaction of groundwater, surface water, storm water, other surface flows, and the affect of contaminants in surface flows on contaminant levels in the aquifers.
10. Require that source water protection plans include an element that addresses recharge areas if groundwater is a part of the supply.
11. Convene a statewide panel to recommend changes to public schools and higher education curricula relating to groundwater. Encourage an integrated academic program on one or more campuses for protection of groundwater quantity and quality and why recharge areas are critical components.
12. Develop a uniform method for analyzing the economic benefits and cost of recharge areas and provide guidance and assistance for economic feasibility analyses that could be used by project planners and funding agencies to assess recharge areas vis-a-vis long-term loss of water supplies, wellhead treatment, or injection wells.
13. Develop a signage program modeled on such programs in other states, that notify people that they are entering an area of critical recharge for the groundwater they use daily, and that disposal of wastes can contaminate their drinking water.

Information Sources

- Biennial Groundwater Conference and Annual Meeting of the Groundwater Resources Association of California Abstracts, 2001, Water Resources Center, University of California.
- California Department of Health Services, *California's Drinking Water Source Assessment and Protection (DWSAP) Program: Guidance and Other Information*, updated 27 May 2003. Available at: www.dhs.cahwnet.gov/ps/ddwem/dwsap/DWSAPindex.htm
- California Department of Water Resources, 2003, *California's Groundwater,* Bulletin 118-2003.
- Driscoll, Fletcher G., Ph.D., 1986, *Groundwater and Wells*, Johnson Division, St. Paul, Minnesota.
- Dunne, Thomas, and Leopold, Luna B., 1978, *Water in Environmental Planning*, W.H. Freeman and Company, San Francisco.
- Fetter, C.W., 1994, *Applied Hydrogeology*, Prentice-Hall.
- Freeze, R.A., and Cherry, J.A., 1979, *Groundwater*, Prentice-Hall, Inc., New Jersey.
- Madrid, Carlos, 1988, Artificial Ground Water Recharge in Southern California, in *Artificial Recharge of Ground Water*, edited by A.I. Johnson and Donald J. Finlayson, American Society of Civil Engineers.
- Sherman, Leroy K., and Musgrave, George W., 1942, *Infiltration*, in *Hydrology,* edited by Oscar E. Meinzer, Dover Publications, Inc., New York.
- U.S. Geological Survey, 2002*, Artificial Recharge Workshop Proceedings, Sacramento, California, April 2-4, 2002*, Open-File Report 02-89.
- U.S. Geological Survey, 2002, *Ground Water and Surface Water, A Single Resource*, U.S.G.S. Circular 1139,
- U.S. Geological Survey, 2002, *Assessing Ground-Water Vulnerability to Contamination: Providing Scientifically Defensible Information for Decision Makers,* U.S.G.S. Circular 1224.
- U.S. Geological Survey, 1983, *Basic Ground-Water Hydrology*, Ralph Heath, Water-Supply Paper 2220.

Recycled Municipal Water

Water recycling, also known as reclamation or reuse, is an umbrella term encompassing the process of treating wastewater, storing, distributing, and using the recycled water. Recycled water is defined in the California Water Code to mean “water which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur.”

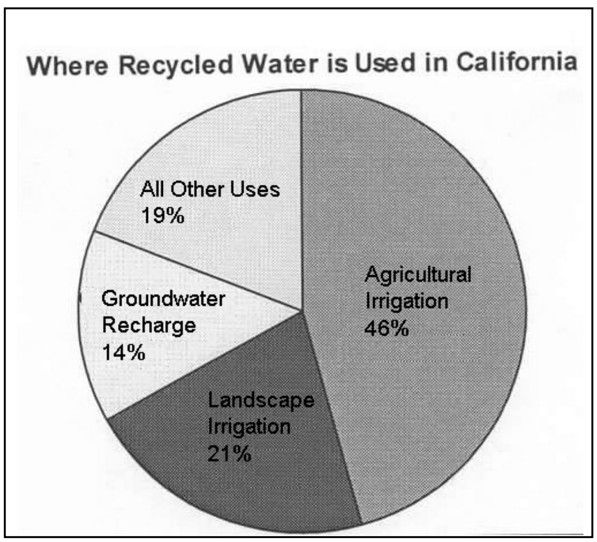
The treatment and use of municipal wastewater for golf course irrigation is an example of water recycling. Higher levels of treatment beyond disinfected tertiary recycled water can make municipal wastewater reusable for school yards, residential landscape and park irrigation, industrial uses or even uses within office and institutional buildings for toilet flushing.

The following discussion of recycled water focuses on treated municipal wastewater. This is wastewater of domestic origin, but includes wastewater of commercial, industrial and governmental origins if such wastewater is commingled with domestic wastewater before treatment. Many industries recycle and reuse their own wastewater. However, due to lack of data, recycling of non-domestic wastewater is not included in the recycling quantity estimates in the following pages.

Current Recycled Water Use in California

Californians have used recycled water since the late 1800s and public health protections have been in effect since the early part of the 1900s. Recycled water use has dramatically increased in the past several decades as water agencies needed to supplement their water supplies. Today, California’s water agencies recycle about 500,000 acre-feet of wastewater annually, almost three times more than in 1970.

The 40-member Recycled Water Task Force was established pursuant to Assembly Bill No. 331(Goldberg, Chapter 590, Statutes of 2001). The Task Force identified opportunities for, and constraints and impediments to, increasing the use of recycled water in California. Over the course of nearly 14 months, the Task Force conducted intensive study in collaboration with many other experts, the public at large, and state staff to develop recommendations (see side bar on following pages) for actions at many levels. The recommendations are not restricted to legislative actions or statutory changes. Many can be implemented by state or local agencies without further legislative authorization or mandate.



California Recycled Water Task Force Recommendations Summary (2003)

Funding for Water Recycling Projects. State funding for water reuse/recycling facilities and infrastructure should be increased beyond Proposition 50 and other current sources. The California Water Commission in collaboration with DWR and SWRCB should seek federal cost sharing legislation for water recycling.

Funding Coordination A revised funding procedure should be developed to provide local agencies with assistance in potential state and federal funding opportunities and a Water Recycling Coordination Committee should be established to work with funding agencies.

Department of Water Resources Technical Assistance. Funding sources should be expanded to include sustainable state funding for DWR's technical assistance and research, including flexibility to work on local and regional planning, emerging issues, and new technology.

Research Funding. The state should expand funding sources to include sustainable state funding for research on recycled water issues.

Regional Planning Criterion. State funding agencies should make better use of existing regional planning studies to determine the funding priority of projects. This process would not exclude projects from funding where regional plans do not exist.

Funding Information Outreach. Funding agencies should publicize funding availability through workshops, conferences, and the Internet.

Community Value-Based Decision-Making Model for Project Planning. Local agencies should engage the public in an active dialogue and participation using a community value-based decision-making model in planning water recycling projects.

State-Sponsored Media Campaign. The state should develop a water issues information program, including water recycling, for radio, television, print, and other media.

Educational Curriculum. The state should develop comprehensive education curricula for public schools; and institutions of higher education should incorporate recycled water education into their curricula.

University Academic Program for Water Recycling. The state should encourage an integrated academic program on one or more campuses for water reuse research and education, such as through state research funding.

Statewide Science-Based Panel on Indirect Potable Reuse. As required by AB 331, the Task Force reviewed the 1996 report of the California Indirect Potable Reuse Committee and other related advisory panel reports and concluded that reconvening this committee would not be worthwhile at this time. However, it is recommended to convene a new statewide independent review panel on indirect potable reuse to summarize existing and on-going scientific research and address public health and safety as well as other concerns such as environmental justice, economic issues and public awareness.

Leadership Support for Water Recycling. State government should take a leadership role in encouraging recycled water use and improve consistency of policy within branches of state government and local agencies should create well-defined recycled water ordinances and enforce them.

DHS Guidance on Cross-connection Control. DHS should prepare guidance that would clarify the intent and applicability of Title 22, Article 5 of the California Code of Regulations pertaining to dual plumbed systems and amend this article to be consistent with requirements included in a California version of Appendix J that the Task Force is recommending to be adopted.

Health and Safety Regulation. DHS should involve stakeholders in a review of various factors to identify any needs for enhancing existing local and state health regulation associated with the use of recycled water.

Stakeholder Review of Proposed Cross-Connection Control Regulations. Stakeholders are encouraged to review Department of Health Services draft changes to Title 17 of the Code of Regulations pertaining to cross-connections between potable and nonpotable water systems.
Cross-Connection Risk Assessment. DHS should support a thorough assessment of the risk associated with cross-connections between disinfected tertiary recycled water and potable water.
Uniform Plumbing Code Appendix J. The state should revise Appendix J of the Uniform Plumbing Code, which addresses plumbing within buildings with both potable and recycled water systems, and adopt a California version that will be enforceable in the state.
Recycled Water Symbol Code Change. The Department of Housing and Community Development should submit a code change to remove the requirement for the skull and crossbones symbol in Sections 601.2.2 and 601.2.3 of the California Plumbing Code.
Incidental Runoff. The state should investigate, within the current legal framework, alternative approaches to achieve more consistent and less burdensome regulatory mechanisms affecting incidental runoff of recycled water from use sites.
Source Control. Local agencies should maintain strong source control programs and increase public awareness of their importance in reducing pollution and ensuring a safe recycled water supply.
Water Softeners. The Legislature should amend the Health and Safety Code Sections 116775 through 116795 to reduce the restrictions on local ability to impose bans on or more stringent standards for residential water softeners. Within the current legal provisions on water softeners, local agencies should consider publicity campaigns to educate consumers regarding the impact of self-regenerative water softeners.
Uniform Interpretation of State Standards. The state should create uniform interpretation of state standards in state and local regulatory programs by taking specific steps recommended by the Task Force.
Permitting Procedures. Various measures should be conducted to improve the administration and compliance with local and state permits. State and local tax incentives should be provided to recycled water users to help offset the permitting and reporting costs associated with the use of recycled water.
Uniform Analytical Method for Economic Analyses. A uniform and economically valid procedural framework should be developed to determine the economic benefits and costs of water recycling projects for use by local, state, and federal agencies.
Project Performance Analysis. Resources should be provided to funding agencies to perform comprehensive analysis of the performance of existing recycled water projects in terms of costs and benefits and recycled water deliveries.
Economic Analyses. Local agencies are encouraged to perform economic analyses in addition to financial analyses for water recycling projects and state and federal agencies should require economic and financial feasibility as two criteria in their funding programs.

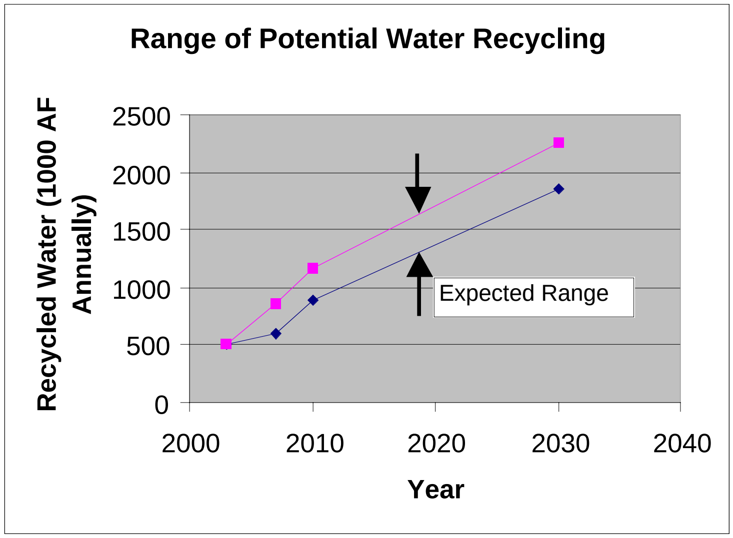
The Task Force recommendations, if implemented, would significantly:

- Improve the way projects are planned
- Increase state and federal financial support for research and project construction
- Improve the regulatory framework
- Lead to advance the use of recycled water as a valuable resource that would significantly mitigate growing water demands as called for by the California Water Code, Sections 13500 et seq.

Progress has begun on several of the Task Force recommendations. For example, the SWRCB issued an Executive Memorandum to Regional Board Executive Officers on February 24, 2004 setting a new framework for regulating of incidental runoff associated with recycled water use. AB 334 (Goldberg, Chapter 172, Statutes of 2003) gives communities additional flexibility to regulate water softeners as a source control measure.

Potential Benefits from Water Recycling

The primary benefit of water recycling is augmenting water supply. Rather than discharging and losing the water, recycled water can be reused as a new water supply. Using recycled water for irrigation can spare high quality potable water currently used for irrigation, making more potable water supply available. There is a potential of about 1.5 million acre-feet of additional recycled water by the year 2030. Of that amount, about 1.2 million acre-feet would be new water supply.



Recycling in some areas may provide new water for the water agency, but not the state. Discharged wastewater in interior California mixes with other water and becomes source water for downstream water users. Only areas, such as coastal areas or areas discharging to an unusable salt sink, add new water supply to the state by recycling wastewater.

For many communities, an investment in recycled water could also provide other benefits:

1. Provide more reliable local sources of water, nutrients, and organic matter for agricultural soil conditioning and reduction in fertilizer use
2. Reduce the discharge of pollutants to water bodies, beyond levels prescribed by regulations, and allow more natural treatment by land application
3. Provide a more secure water supply during drought periods
4. Provide economic benefits resulting from a more reliable water supply
5. Improve groundwater and surface water quality and contribute to wetland and marsh enhancement.
6. Provide energy savings; the use of recycled water as a local source offsets the need for energy-intensive imported water

Potential Costs of Recycled Water

The estimated capital cost for 1.5 million acre-feet of more recycled water is about $11 billion. The actual cost will depend on the quality of the wastewater, the treatment level to meet recycled water intended use, and the availability of a distribution network. Uses, such as irrigation near the treatment plant, will benefit from lower treatment and distribution costs. Irrigation of a wide array of agriculture and landscape crops can even benefit from the nutrients present in the recycled water by lowering the need for applied fertilizer. However, the use of recycled water for irrigation without adequate soil and water management may cause accumulation of salts or specific ions in soil and groundwater. Some uses, such as an industrial process located farther away from the treatment plant, may need to pay higher costs for treatment and distribution. Given the wide range of local conditions that can affect costs, the majority of applications would cost between $300 and $1,300 per acre-foot of recycled water. Costs outside this range may be plausible depending on local conditions. Uses that require higher water quality and have higher public health concerns will have higher costs.

Major Issues Facing More Recycled Water Use

There are major issues facing more recycled water use.

Affordability

The cost of recycled water, relative to other water sources, will influence how much recycled water is produced for each region. The costs are dependent on the availability of treatable water, demand for treated water, the quality of the source as well as the product water, the type of the intended beneficial use, and the proximity of recycled water facilities to the end users. The lack of adequate local funding to plan feasible recycled water projects can slow the construction of new projects. Public funding as well as incentive measures can help advance water recycling projects that provide local, regional and statewide benefits. The cost of recycled water can influence water markets, especially if recycled water is available for transfer.

Water Quality

The quality of the recycled water will affect its usage. Public acceptance of recycled water use is dependent on confidence in the safety of its use. Four water quality factors are of particular concern: (1) microbiological quality, (2) salinity, (3) presence of toxicants of the heavy metal type, and (4) the concentration of stable organic and inorganic substances or emerging contaminants originating from various pharmaceuticals and personal care products, household chemicals and detergents, agricultural fertilizers, pesticides, fungicides, animal growth hormones, and many other sources. The salinity of recycled water can limit its usefulness for some applications such as salt sensitive landscaping, golf courses, and agriculture. Each use of water generally adds salt to the water. In particular, the use of water softeners adds salt to the water. Also, water conservation can further concentrate salts. Hence, the resulting wastewater, that is high in salts, would be more difficult and expensive to recycle. There is generally a limit to how many times water can be recycled unless a more expensive treatment technology, such as reverse osmosis, is used to remove the salts (see the Desalination strategy).

Public Acceptance

Public perception and acceptance of some recycled water uses currently limits its application. In some areas, public concerns about potential health issues have limited the use of recycled water for indirect potable purposes and even for irrigation of parks and school yards.

Potential Impacts

Areas in interior California that discharge their wastewater to streams, rivers, or the groundwater contribute to downstream flows. Recycling water would remove this source of water and potentially affect downstream water users including the environment. In some instances, recycling is discouraged when dischargers are required to maintain a certain flow in the stream for downstream users.

Recommendations to Increase Recycled Water Usage

State and local agencies and various stakeholders should actively follow up with the implementation of the Recycled Water Task Force recommendations (see above sidebar on Task Force recommendations) as they constitute a culmination of intensive study and consultation by a statewide panel of experts drawing upon the experience of many agencies. Such recommendations provide advice that can be used as a toolbox for communities to improve their planning of recycled water projects.

Information Sources

- Water Recycling 2030, California Recycled Water Task Force Report, 2003.
- SWRCB, California Municipal Wastewater Reclamation Survey, 2003.
- Water Recycling 2000, California's plan for the future. State Water Conservation Coalition, Reclamation/Reuse Task Force and the Bay Delta Reclamation Sub-Work Group, 1991.
- Southern California Comprehensive Water Reclamation and Reuse Study, Phase II. Final Report (Draft), 2000.
- Other Reports such as DWR Water Recycling Survey, 1993, California Water Plan Update 1998.

Surface Storage – CALFED

The CALFED Record of Decision identified five potential surfaces storage reservoirs that are being investigated by the California Department of Water Resources, U.S. Bureau of Reclamation, and local water interests. Implementation of one or more of the potential reservoirs would be part of CALFED's long-term comprehensive plan to restore ecological health and improve water management for beneficial uses of the Bay-Delta. The five surface storage projects under investigation are:

- Sites Reservoir (North-of-the-Delta Offstream Storage)
- In-Delta Storage
- Shasta Lake Enlargement (Shasta Lake Water Resources Investigation
- Los Vaqueros Reservoir Enlargement
- Millerton Lake Enlargement or a functionally equivalent storage program in the region (Upper San Joaquin River Basin Storage Investigation)

The surface storage regional/local strategy gives a broader background of surface storage in California that may also be helpful to the reader related to the following discussion of CBD Surface Storage. Details and project-specific descriptions of the investigations can be found in the California Bay-Delta Surface Storage Program Progress Report in Volume 4, Reference Guide.

Current Status of CALFED Surface Storage

A multidisciplinary CALFED interagency team originally began with a list of 52 potential reservoir sites and screened those to 12 sites that appeared to contribute to CALFED goals and satisfy CALFED solution principles, objectives, and policies. Sites smaller than 200,000 acre-feet of storage were considered too small to materially contribute to the program. In addition, CALFED policy focused on offstream reservoir sites and consideration of existing reservoir expansions. The five storage investigations identified in the ROD appeared to be more promising in their ability to contribute to CALFED's ecosystem, water quality, flood control and water supply objectives. Planning for the five CALFED-directed investigations has made varying levels of progress. Each investigation is considering a reasonable range of alternatives. Current timelines have targeted 2006 – 2008 for completing the planning documents. Essentially, the planning consists of project formulation, environmental documentation and engineering design. As relevant and useful information becomes available, both stakeholders and the public are notified to ensure that a broad array of input and response are incorporated into the planning activities and documentation. More specifically, as project costs, environmental effects, and benefits are compiled, regulators, the public, and ultimately decision-makers will be asked to respond to the evaluations and conclusions.

Ongoing Surface Storage Investigations

The planning process for surface storage is both comprehensive and demanding. The CALFED surface storage investigations have been developed to comply with both the state and federal environmental laws, which require extensive documentation and public involvement. In addition, implementation of any one would likely require more than 30 regulatory permits and compliances. The timing and size limitations of the characterizations here are both incomplete and brief. Both the environmental laws and the permits and compliances will allow the public to participate in a more comprehensive and informed manner and on specific issues at the appropriate time. For more information related to public involvement in the investigations, visit www.storage.water.ca.gov/index.cfm

The five investigations are being completed under the programmatic direction provided by the CALFED ROD and the CBD Authority. The ROD includes a number of Implementation Commitments and Solution Principles to guide potential project implementation. For example, a fundamental philosophy of the CALFED Program is that costs should, to the extent possible, be paid by the beneficiaries of the program actions. The CALFED Program has also provided a forum for independent scientific review of important project-related issues through development of a Science Program with expert panels. In addition, the CBD agencies have committed to science-based adaptive management that would allow their facilities operations to be modified as understanding of issues improves or new issues are identified.

Two locally developed reservoirs, Los Vaqueros in northern California and Diamond Valley in the southern state, have been completed within the past six years are examples of offstream surface storage development. CALFED's program focus on offstream reservoirs or expansion of existing facilities, highlights the desire to reduce or avoid significant environmental effects. In addition, the use or objectives of Los Vaqueros (100,000 acre-feet capacity) and Diamond Valley, (800,000 acre-feet capacity) have focused on benefits other than the traditional energy generation, flood control, and water supply. The primary benefits of these new reservoirs are related to water quality, system flexibility, and system reliability against catastrophic events and droughts. More specifically, water supply augmentation is not a primary objective of either reservoir. The CALFED surface storage investigations reflect a similar approach, identifying the need for system flexibility and water quality. However, the ROD also identified water supply reliability and ecosystem restoration as primary surface storage objectives as well.

Los Vaqueros and Diamond Valley Reservoirs

Los Vaqueros and Diamond Valley help illustrate a potential misunderstanding of benefits in applying traditional economic evaluation methods to surface storage planning efforts. Traditional economics would evaluate storage projects based on cost per acre-foot of water supply improvement. Since these projects were constructed for other benefits, the "yields" of these reservoirs are incidental. Traditional cost per acre-foot evaluation would generate almost infinite unit cost. Similarly, application of traditional water supply economics for surface storage is likely not appropriate in many cases, including the CALFED surface storage investigations that focus on operational flexibility, water quality, environmental flows or other nontraditional benefits.

A common assumptions process has been developed to assure that the CBD Surface Storage analyses use a consistent basis for comparison, and that the planning assumptions are based on the most current rules, regulations, and operations. All five surface storage investigations will use a common set of existing and future no-action baseline conditions for assessing the feasibility, benefits, and impacts of the various projects. However, the CBD Surface Storage Program cannot wait for final key milestone project decisions such as recently considered proposed operational agreements before incorporating common assumptions into its models. The program will begin using the best available assumptions for all five storage projects. As assumptions require revisions, the projects will adopt the new assumptions in future studies.

Work completed on the five investigations over the past several years is approaching a point where this initial information on project performance and costs can be provided to local and regional agencies. The investigations are now developing operational scenarios that will allow potential beneficiaries the ability to assess their interest in specific projects. Bay-Delta Authority staff, along with federal and State agencies, are developing a conceptual finance plan, including disclosure of state and federal policies for repayment of project benefits and a determination of project features and operations that benefit the entire State. This effort will include a variety of possible financing mechanisms and cost allocation methods.

Potential Benefits from CALFED Surface Storage

CALFED noted that perhaps the greatest benefit of new surface storage would be the operational flexibility that storage adds to the currently constrained system. The Bay-Delta system provides water for a wide range of needs, including in-stream flows for aquatic species, riparian habitat, wetlands, as well as benefits to municipal, industrial, and agricultural users. These often competing demands have restricted the operational flexibility of the SWP and CVP systems and consequently negatively impacted the quantity, quality, and timing of deliveries. The inflexibility and resulting consequences are then passed along to water users that are partially or wholly dependent upon the operations or deliveries of the CVP and SWP systems. By storing additional water, new surface storage can contribute to improved operational flexibility in the SWP and CVP systems and associated users for the enhanced statewide water resources benefits described below.

Each of the five surface storage reservoirs could be used to improve water supply reliability. The surface storage projects could also improve source water quality directly or facilitate blending of water from different sources. New surface storage can help provide water for the CALFED Environmental Water Account and other environmental needs. New surface storage can also help reduce the risk associated with potential future climate change by mitigating the effects of a relatively smaller seasonal snowpack storage capacity. Implementation of individual surface storage reservoirs could augment average annual water deliveries by anywhere from a negligible amount to over 400,000 acre-feet (according to initial operations simulations), depending on the mix of benefits selected by beneficiary agencies and operational considerations.

The total amount of potential water supply improvements from implementation of all five surface storage projects is unknown since a cumulative operations study has not yet been modeled. A cumulative study will be part of the common assumptions effort. However, initial model simulations show that the potential reservoirs could provide a wide range of type and geographic scope of benefits including agricultural, ecosystem, and urban uses, improvement of Delta water quality for both the ecosystem and Delta users and exporters, improvement of streamflows during times critical for fisheries and other ecosystem processes, flexibility for changing the timing of existing diversions to protect fisheries, and other water management purposes.

Other strategies can be more effective with additional storage. For example, water transfers can be more easily accommodated if water can be stored temporarily and then released from upstream storage at appropriate times and the receiving areas have capacity to store the transferred water. In addition, surface storage can improve the effectiveness of conjunctive water management strategies by more effectively capturing runoff that can ultimately be stored in groundwater basins.

Potential Costs of CALFED Surface Storage

Funding for the CALFED surface storage investigations has been provided by Federal and State funding sources, including voter-approved bond funds. A total of $69.3 million ($46.7 million State, $22.6 million Federal) has been spent on the five CBD Surface Storage investigations from fiscal years 2000-2001 through 2003-2004. DWR and Reclamation will need an estimated additional $40.9 million in study funding through 2005-2006.

New feasibility engineering cost estimates are in various stages of development for each of the five surface storage investigations. Costs will depend on project selected objectives and configurations. The estimated capital cost for developing the individual surface storage projects identified in the CALFED ROD could range from $180 million for the smallest Shasta Lake Expansion, to $2.4 billion for Sites Reservoir with the most extensive conveyance facilities; the least expensive configuration of Sites Reservoir could be about half as much as the most expensive. These costs do not include anticipated annual costs such as operations and maintenance, power, or costs associated with the use of existing facilities. As the investigations continue to move forward, more complete descriptions of costs and more specific allocation of benefits will allow an economic evaluation where costs can be assigned to specific beneficiaries and benefits. Under CALFED's "beneficiaries pay" concept, all beneficiaries including water quality, environmental, system flexibility, and water supply reliability beneficiaries would pay for their share of each project's benefits. Implementation of any of the five potential surface storage projects would likely include some state and federal public funding to pay for public benefits.

Major Issues Facing CALFED Surface Storage

Identification of Beneficiaries

While the ROD identified potential project purposes for the five surface storage projects, it did not specify how those benefits would be distributed, who would receive them, or how the costs of the projects would be allocated. To comply with federal and state planning requirements, DWR and Reclamation must identify more specific project purposes, operational plans, and end uses of benefits that could be developed by the projects. While this will require the active participation of local and regional water agencies, those agencies must have initial information on the benefits the projects might provide and the potential costs that might be allocated to them before they can be expected to engage.

Funding

The surface storage analyses, planning documentation, and permitting require major investments. Providing continuity of funding over the long development period is a major challenge. After fiscal year 2003-2004, less than $20 million from relatively stable State funding sources will be available for work on the five storage projects. To date, Federal funding has been a limiting factor in meeting the ROD schedules. Inadequate funding extends schedules and raises time dependent expenses, resulting in increased project costs. Without sufficient and stable funding, prioritization and potential deferral of specific projects may be required.

Impacts

New surface storage can cause impacts within the reservoir inundation area affecting the existing environment and human uses, economic impacts for the surrounding community, and flow impacts both up and downstream of diversions. A number of social and economic effects are being considered in the investigations such as loss of agricultural lands, changes to the mix and type of jobs, and loss of property tax revenue to local governments. The surface storage investigations are also considering environmental effects such as potential impacts to stream flow regimes, potential adverse effects to a protected stream, potential water quality effects, potential changes in stream geomorphology, and loss or conversion of fish and wildlife habitat. New surface storage projects may need to address impacts under the application of various laws, regulatory processes and statutes including Public Trust Doctrine, Area of Origin statutes, CEQA, NEPA, the Clean Water Act and the Endangered Species Acts. More specific descriptions of the types of potential impacts associated with the five investigations are noted in the Progress Report (see Volume 4, Reference Guide) of the five surface storage investigations. As noted in the Record of Decision, decisions to construct surface storage will be predicated on compliance with all environmental review and permitting requirements.

Recommendations to Help Promote Implementation of CALFED Surface Storage

1. CALFED signatories and stakeholders should finish the feasibility and environmental studies of the five potential surface storage projects identified in the CALFED ROD.
    - The investigations should continue to test all five potential projects against CALFED Solution Principles and Implementation Commitments as well as other local, state, and federal planning criteria for deciding to move to construction of any projects.
    - Engage more stakeholders and potential project beneficiaries in the process.
    - Develop complete information on how the projects could be operated for a variety of purposes, costs, and impacts.
    - Continue evaluation and presentation of operational scenarios that will allow potential beneficiaries to assess their interest in specific projects.
    - Develop mechanisms to provide assurances that projects will be operated in a manner consistent with the objectives.
2. The CBDP, DWR, and Reclamation should continue their development of conceptual finance plans that will include descriptions of relevant State and Federal financial policies and a determination of the potential for State and Federal investment in benefits to the general public. The scenarios and finance plans will help facilitate potential investment decisions by local, regional, State and Federal decision-makers.

Information Sources

- CALFED Programmatic EIS/EIR and ROD
- North-of-the-Delta Offstream Storage Investigation Progress Report July 2000
- North-of-the-Delta Offstream Storage Scoping Report, October 2002
- Initial Surface Water Storage Screening Report, CALFED August 2000
- Contra Costa Water District's Draft Project Concept Report, CALFED August 2002
- In-Delta Storage Program Draft Summary Report and supplemental reports on operations, water quality, engineering, environmental, and engineering evaluations May 2002
- Flow Regime Requirements for Habitat Restoration along the Sacramento River between Colusa and Red Bluff, Revised February 14, 2000
- Upper San Joaquin River Basin Storage Investigation Draft Phase 1 Investigation Report In-Progress Review, Initial Surface Storage Options Screening, November 2002
- Shasta Lake Water Resources Investigation Mission Statement Milestone Report, March 2003
- California Bay-Delta Surface Storage Program Progress Report, April 2004

Surface Storage - Regional/Local

Surface storage is the use of reservoirs to collect water for later release and use. Surface storage has played an important role in California where the pattern and timing of water use does not always match the natural runoff pattern. Most California water agencies rely on surface storage as a part of their water systems. Similarly, surface storage is often necessary for, or can increase, benefits from other water management activities such as water transfers, conjunctive management and conveyance improvements. Some reservoirs contribute to water deliveries across several regions and some only contribute to water deliveries within the same watershed. Surface reservoirs can be formed by building dams across active streams or by building off-stream reservoirs where the majority of the water is diverted into storage from a nearby water source. Surface storage capacity can also be developed by enlarging, reoperating or modifying outlet works on existing reservoirs. Smaller reservoirs typically store water in one season for use in another season, while larger reservoirs can do the same or store water for use over several years. Reoperation of facilities is treated in a separate strategy narrative.

This Strategy covers regional and local surface storage alternatives not currently under state and federal investigations as described in the CALFED Record of Decision. The potential CALFED storage is intended to help meet CALFED goals and objectives which are not statewide in nature. Additional regional and local surface storage may be needed to help meet multiple statewide needs. The potential CALFED surface storage projects are described in a separate strategy narrative.

Current Surface Storage in California

California currently has nearly 200 surface storage reservoirs greater than 10,000 acre-feet with a combined storage capacity of more than 41 million acre-feet. In addition, many smaller reservoirs are used to provide for a wide range of water uses, stabilize water delivery to customers and provide a backup for emergency supply. Similar to many other parts of the world, most California reservoirs were developed over 30 years ago. As of the mid-1990s, there were about 1,242 dams[1] being built worldwide – 55 in the United States. In California, nearly 40 dams[2] have been built over the past decade. Examples of recently completed surface storage reservoirs completed by local/regional entities include: Olivenhain, Los Vaqueros, Diamond Valley and Seven Oaks reservoirs. The primary benefits of these new reservoirs are related to flood control (Seven Oaks), water quality, system flexibility, and system reliability against catastrophic events and droughts rather than for traditional water supply.

Over the past several decades, fisheries have received improved benefits from surface storage reservoirs through regulation and legislation. Specifically, many existing reservoirs have been managed to achieve ecosystem and other benefits beyond water supply. As both environmental and urban uses have grown, the state’s surface water system has become increasingly inflexible. Water and ecosystem managers have less ability to adapt as use and regulatory requirements frequently control operations.

The relative need for local surface storage development may be greatest in the interior mountainous areas of the state such as the Cascades and the Sierra Nevada. Although much of the water used throughout the state originates in the mountains, these locations generally possess a much narrower array of available water management strategies to meet local needs. This is largely due to geographic, hydrogeologic or

[1] United States Society on Dams, November 2000
[2] Source: CA Division of Safety of Dams; includes DSOD jurisdictional dams only.

hydrologic limitations. Of these few strategies, some form of surface storage may hold the greatest potential for achieving local supply reliability objectives. Local surface storage development options include the reoperation of existing reservoirs, increasing the yield of existing reservoirs through expansion of their capacity, or construction of new reservoirs.

Potential Benefits of Surface Storage

Many of California's reservoirs were originally built for the primary purposes of hydropower, flood control, and consumptive water use. Although the allocation of benefits for proposed surface storage can affect the occurrence and magnitude of different types of benefits, they generally can include the following:

- Water quality management
- System operational flexibility
- Power generation
- Flood management
- Ecosystem management
- Sediment transport management
- Recreation
- Water supply augmentation
- Emergency water supply

The presence of new surface storage could allow ecosystem and water managers the flexibility to take actions and make real-time decisions that would not be possible without the storage. More water transfers between regions could be easier if water can be released from upstream storage at appropriate times and the receiving regions have reservoirs to store the transferred water. Surface storage can improve the effectiveness of conjunctive water management strategies by more effectively capturing runoff that can ultimately be stored in groundwater basins.

Storage projects can improve the movement of water at times to improve source water quality directly or facilitate blending of water from different sources to optimize system water quality. New surface storage can help provide water resources assets for the CALFED Environmental Water Account and Environmental Water Program, and for refuges. New surface storage can also help reduce the risk associated with potential future climate change by mitigating the effects of a relatively smaller seasonal snowpack storage capacity as well as increased or more sustained peak flood flows.

Potential Costs of Surface Storage

Cost estimates for potential surface storage alternatives are not specified in this narrative since they are only useful if created for a specific project with defined operation rules and allocation of benefits and costs. The costs of multipurpose storage projects will be shared by many beneficiaries. The magnitude of the benefits and corresponding costs for water supply, water quality, flood management, etc. can be expected to vary significantly from project to project.

Major Issues Facing Surface Storage

Identifying Beneficiaries

There are concerns related to how the beneficiaries will be determined, who will actually pay, and who will control the storage operation. The challenge is to develop financial and operations agreements for the multiple beneficiaries and uses.

Funding

Construction usually requires large sums of money over a short time period -- perhaps $1 billion or more over five years for larger projects. Included in the long-term capital outlay are planning costs such as administrative, engineering, legal, financing, permitting and mitigation which can also require significant investments. Some new storage options such as raising existing reservoirs, reoperating them or the construction of small local reservoirs may require significantly less capital cost, but may require local funding through revenue or general obligation bonds. Even these less costly projects would face financial challenges.

Impacts

New storage can affect the existing environmental and human conditions, create economic impacts for the surrounding community, and flow impacts both up and downstream of diversions. New reservoirs may impact local land use resulting in the loss of property tax revenue to local governments in the area they are located, or by increasing local property values by firming up a water supply. Regulatory and permitting requirements require surface storage investigations to consider potential impacts to stream flow regimes, potential adverse effects on designated wild and scenic rivers, potential water quality issues, potential changes in stream geomorphology, loss of fish and wildlife habitat, and risk of failure during seismic and operational events. New surface storage projects may need to address impacts under the application of various laws, regulatory processes and statutes such as Public Trust Doctrine, State dam safety standards, Area of Origin statutes, CEQA, NEPA, the Clean Water Act and the Endangered Species Acts.

Suitable Sites

Most of the best reservoir sites have already been used and the new standards of environmental regulations are significant constraints to development of surface storage in the mountains. The range of surface storage development options for smaller local agencies is more limited than for the state and federal governments. Local agencies have limited ability to use state or federal funds, nor do they have the ability to work as closely with their corresponding resource regulatory agencies such as the state and federal agencies do as part of CALFED, for example. Additionally, there are physical limitations on storage options in some parts of the state. In some areas, offstream storage is not feasible. These circumstances severely constrain the ability of water resources entities within these geographic areas to locally finance and implement the projects necessary to sustain the local economy and serve increasing populations.

Science

Biologists and water managers continue to struggle to identify and understand the relationships between hydrodynamics, flow timing, water temperature, geomorphology, water quality, environmental responses, and other conveyance related considerations. Increased understanding of these considerations will enable resource planners and managers to better determine the causes of observed impacts and hence, more effectively restore, preserve and manage at-risk resources, such as modified operations and environmental mitigation.

Recommendations to Better Manage and Increase Surface Storage Benefits

1. Local agencies seeking to implement storage projects should develop a comprehensive methodology for analyzing all benefits and full costs of projects. DWR should provide technical expertise and assistance to the local agencies upon request.
2. Reservoir operators and stakeholders should continue to adaptively manage operations of existing facilities in response to increased understanding of system complexities and demands as well as changes in natural and human considerations such as social values, hydrology, and climate change.
3. DWR and other local, state and federal resource management agencies should continue studies, research and dialogue focused on a common set of tools that would help determine the full range of benefits and impacts as well as the costs and complexities of surface storage projects.
4. Water resources scientists, engineers and planners, including DWR should recognize the potential long development time for new surface storage in securing funding needed for continuity of planning, environmental studies, permitting, design, construction, and operation and maintenance.

System Reoperation

System reoperation consists of changing existing operation and management procedures for water facilities to meet competing beneficial uses. System reoperation could be used to rebalance existing uses, improve the efficiency of existing uses, or improve some uses and decrease others. In some cases, physical modifications to the facilities may be needed to expand the reoperation capability.

Population growth, with its commensurate demand for new water supplies, better understanding of the environmental impacts of water development, and changing laws and values, has created incentives to evaluate how existing facilities can be reoperated to provide the best use of the facilities.

Examples of System Reoperation

- Changes in timing or volume of reservoirs water storage and releases to accommodate changing priorities of the project, such as improving instream conditions, recreation opportunities, flood management, local water supplies, or managing water quality.
- Using temperature control devices in reservoirs to permit water to be released from variable depths in order to manage the water temperature and water quality downstream for endangered species protection while maintaining hydroelectric power generation.
- Increasing the water storage and flood retention capacity of reservoirs by conveying reservoir water to groundwater banks before the refill season.
- Coordinating water storage, water conveyance, and water delivery systems within a watershed or geographic area to improve benefits to the local watershed area, the regional watershed area, and the state.
- Balancing water supply and delivery forecasts with the economic and environmental risks that water users and regulatory agencies may be willing to accept if full deliveries are not met. The ability to customize risk tolerances to users may allow overall improvements in system efficiency.

Current Extent of System Reoperation

System reoperation is not a new tool for water managers. The 1976-1977 drought prompted many water agencies to move away from the “firm yield” approach to operating water projects to a risk based approach when making system delivery decisions. The firm yield approach seeks to deliver the same amount every year regardless of water supply conditions while the risk based approach balances increasing deliveries in a given year with the risk of not meeting full deliveries in a future dry year. The risk-based approach has increased average deliveries of the State Water Project. Several large-scale regulatory and water planning and management efforts started over the last decade have prompted project operators to explore system reoperation. These efforts include implementation of the Central Valley Project Improvement Act (CVPIA), SWRCB Bay Delta Decision 1641, and hydroelectric facility relicensing. Concerns about the potential effect of global climate change have also influenced reoperation planning.

The CVPIA, signed into law October 30, 1992, mandated changes in management of the Central Valley Project, particularly for the protection, restoration, and enhancement of fish and wildlife. This has led to changes in the terms of water supply contracts, reallocation of water for environmental benefits, increased use of voluntary water transfers, and implementation of water use efficiency measures. One example of reoperation that was prompted by CVPIA was the installation of the Temperature Control Device (TCD) at Lake Shasta Dam at a cost of $80 million. The TCD is a shutter type mechanism designed to draw water from the different levels of Shasta Lake and release it through powerhouse turbines, providing cold water for endangered Winter Run Chinook salmon spawning downstream in the Sacramento River, while maintaining hydroelectric power generation. Water is drawn from different levels of the lake at different times of the year to match the downstream requirements and to manage the cold water reserves behind the reservoir.

The State Water Resources Control Board adopted Decision 1641 (D-1641) on December 29, 1999. The Decision implements flow and water quality objectives for the Bay-Delta Estuary set forth in the1995 Bay-Delta Plan, adopted May 22, 1995. D-1641 recognizes that many of the objectives in the 1995 Bay-Delta Plan are best implemented by making changes in the flow of water or in the operation of export facilities. Accordingly, D-1641 includes aspects of system reoperation by approving changes to points of diversion of the Central Valley Project and the State Water Project in the southern Delta, and approving changes in places of use and purposes of use of water developed and distributed by the Central Valley Project.

Approximately one third of hydroelectric facilities in California licensed by the Federal Energy Regulatory Commission (FERC) must undergo review and relicensing by 2015. Because FERC issues licenses for a period of 30-50 years, relicensing provides an opportunity to assess and change license conditions for many facilities over a relatively short period. Many of these facilities were designed, constructed, and licensed before the modern environmental laws like CEQA and NEPA were in effect and before the California Supreme Court clarified, in National Audubon Society v. Superior Court of Alpine County (1983), the State's public trust responsibilities to protect the people's common heritage of streams, lakes, marshlands and tidelands. The result is that many facilities did not fully evaluate potential impacts to rivers in the timing and volume of instream flows, sediment transport, water temperature, and fish passage. Operational changes are being made during relicensing to ensure that the projects are in compliance with modern environmental laws, public trust, public policy and the public interest.

Global climate change has also prompted discussion of system reoperation. The specific effects of global climate change on water resource management in California are uncertain. Climate change could result in altered snowpack accumulation and melting, runoff patterns, water supply, sea level, floods and droughts, water demands, water temperature, plant and animal life including livestock, hydroelectric power, wild fires, recreation, water quality, soil moisture, groundwater, and ecosystems. The California water planning community continues to evaluate climate change and study ways of incorporating flexibility and robustness into the current system to respond to climate change.

Potential Benefits of System Reoperation

Statewide benefits of system reoperation are difficult to estimate since the potential benefits are generally project specific. Future implementation of the CALFED Environmental Water Account is expected to provide approximately 150 TAF of water from willing sellers by reoperating local and regional surface water projects. The State Water Project and Central Valley Project have integrated operations since the 1970's with annual agreements that were eventually finalized in 1986 with the signing of the Coordinated Operating Agreement. This agreement has led to significant improvement in how water is provided by the two projects to meet in basin and environmental uses.

System reoperation integrates multiple resource management strategies such as surface storage, conveyance facilities, conjunctive management, water-dependent recreation and ecosystem restoration, which can:

- Reduce conflicts between competing beneficial uses and allow for improvements to the beneficial uses including environmental, recreational, water quality, and water supply objectives.
- Provide additional flexibility to respond to extreme hydrologic events like flood and drought or catastrophic events like earthquakes.

Potential Costs of System Reoperation

The potential direct costs for implementing system reoperation are project specific and are difficult to extrapolate to a statewide estimate. Up-front costs may include performing the feasibility studies, completing CEQA/NEPA analysis, and undergoing water rights permitting to implement a proposed change in operation. These studies alone can cost millions of dollars and take several years to complete. Long-term costs may include capital costs for the construction, modification, or removal of facilities, loss of revenue from reduction in sale of hydropower or water supplies, and increased operations and maintenance costs.

Major Issues Facing System Reoperation

The major issues facing system reoperation are:

Reduced Hydropower Generation

System reoperation has the potential of shifting some water use from power generation to other beneficial uses. Preliminary analyses by the California Energy Commission indicate that project specific and cumulative losses associated with FERC relicensing to date are not significant on a system-wide basis in California. Many facilities must still undergo relicensing and the effects of these on energy generation must be evaluated. Improved generating equipment and technology can offset some of this energy reduction. There may be a need to provide for alternative sources of energy to make up any reduction in hydropower generation. If reoperation occurs on a large scale, switching to fossil fuels to offset this loss could increase air pollution, and reliance on imported energy sources.

Gaps in Scientific Knowledge and Data

There are several significant knowledge gaps that should be addressed to improve the likelihood of successful system reoperation. There is a need for greater understanding of the relationships between flow patterns, the response of aquatic ecosystems, and how these relate to protecting public trust resources. While this area of applied environmental science is developing quickly, there is a need to improve the understanding of the effects of pulsed and ramped flows upon endangered species, other aquatic species, habitats, and river morphology. Lack of baseline data and good bio-hydrologic models for some ecological components are limiting factors. Biological opinions issued by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service provide some guidance on specific changes in operation that would benefit the specific endangered species covered by the opinion. There is also a gap in the understanding of the specific effects associated with global climate change on local water systems. Changes in the timing and distribution of precipitation and runoff within the state may create greater uncertainty, potentially requiring changes to the management of the water system. There is a need for improved runoff prediction and decision support systems to balance competing water needs.

Case Example of System Reoperation El Dorado Irrigation District's Project 184

El Dorado Irrigation District's (EID's) Project 184 highlights the potential benefits, costs, and issues surrounding system reoperation as part of FERC relicensing. Project 184 is a 21 Megawatt hydroelectric and water supply project located on the South Fork of the American River and its tributaries, and on Echo Creek, a tributary to the Upper Truckee River, in the Counties of El Dorado, Alpine, and Amador, California.

In February 2000, EID filed an application to renew its license with FERC. The relicensing of Project 184 involved a collaborative process to provide significantly enhanced environmental protection, improving recreational opportunities and for assuring the long-term reliability and economic viability of local water supply. In April 2003, the effort produced a settlement agreement, which has been filed with FERC as recommendations for establishing conditions for the new license:

- Lake Level criteria for improved recreation opportunitiesImproved aquatic habitat via new stream flow criteria in more reaches of streamPulse flows in regulated reaches to mimic natural hydrologic condition peak flowsRecreation facility improvements including a new boat ramp, campground access improvements, whitewater boating access improvementsFish screens at diversions from Alder and Carpenter CreeksPublic information system of real-time lake and flow data via internet & phoneStream restoration in previously scoured reachesSensitive species, fish and water quality monitoring Various environmental protection plans for O&M and future capital projects Ecological resources adaptive management program

Although implementation of the new license conditions may result in a slight reduction in revenues depending on future power values, revenues from power generation can be augmented with revenues from consumptive water deliveries in order to fund project costs. EID benefits by maintaining the power generation features of the project because revenues from hydroelectric power generation offset the majority of project costs which are largely driven by the cost of water conveyance, an integral system component that would exist with or without power generation capability.

Even with the collaborative process and settlement agreement, the proposed reoperation is not entirely free of controversy. At least one interested party representing some of the recreation and business interests around Caples and Silver Lakes has not signed on to the settlement agreement because of concerns about potential economic and quality of life impacts from the revised operation. Although lake level and streamflow conditions under the system reoperation would generally be enhanced for recreation interests compared to historic project operations, disagreement continues over what lake levels should be maintained during the summer and fall recreation season, if the lakes refill from year to year, and how low lake levels will be allowed to drop during dry years.

Competing Beneficial Uses

In some cases, the analysis of reservoir reoperation can be as complex and controversial as that associated with new facility construction. Because many water facilities have been operating the same way for decades, it is important to consider the interests of current beneficiaries before introducing dramatic changes. For example, many reservoirs have existing uses including recreation, summer homes, wetland habitat, fisheries, etc. In addition, reoperation could have unintended impacts to existing ecological processes that must be evaluated. There is concern about potential direct and indirect impacts on other users including downstream water rights, the environment, recreational uses, and energy production.

Conveyance Constraints

The capacity of reservoir outlets, storage, pumping, and conveyance may limit the ability to perform system reoperation through water transfers, conjunctive management, revised flood operations, and other operations.

Area of Origin Water Rights

Historically, area of origin water rights have not been widely exercised, but they are increasingly of interest as rural counties develop. It may be possible for these areas to develop agreements with project operators to meet some of these projected demands through reoperation of existing facilities rather than through construction of new facilities. However, new facilities may provide more flexibility to the overall management of the system. Agreements with existing facility operators to change operations would need to consider existing uses.

Integrating Water Resource Management

There are many tiers of management of developed water resources. These include facilities that are operated for local, regional, or statewide beneficial uses. Implementing system reoperation to obtain wider system benefits can require regulatory actions by several local, state, and federal agencies. For example, hydropower relicensing may include actions by the California Department of Fish and Game, the State Water Resources Control Board, the U. S. Forest Service, U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the Federal Energy Regulatory Commission. Efforts to increase coordination among both the physical operation of the facilities and the regulatory agencies may result in greater opportunities to achieve broader benefits within each watershed.

Implementation Costs

Significant up-front and on-going costs can be involved with system reoperation. Costs may include developing monitoring systems, hydrologic models, decision support systems, and collecting data to evaluate benefits and impacts of proposed changes. Other costs are associated with conducting feasibility studies, completing CEQA/NEPA analysis, and constructing new or modifying or removing existing facilities. Agencies may have difficulty raising the needed funds due to existing contracts or regulations that prohibit them from increasing water or energy rates.

Water Quality

Water quality may restrict the ability to modify existing operations for other benefits. For example, the need to maintain cold water temperature reserves in reservoirs for downstream fisheries may prohibit reducing reservoir storage levels during the certain seasons for water supply. Reoperation using surface water to actively recharge groundwater banks may be limited by existing groundwater or recharge water quality. Water quality is often more critical for reoperation for local benefits than for regional and statewide benefits.

Recommendations to Further System Reoperation

1. The following recommendations are derived from the California Energy Commission's Public Interest Energy Research Program to gain a better understanding of the effects of flow release patterns on California stream habitats and biotic communities:
    a. Review the quality and available scientific data on the ecological impacts.
    b. Determine the adequacy of current and new sampling and analytical methods to detect and predict potential effects.

   c. Develop a recommended protocol for assessing possible ecological impacts.
   d. Develop and disseminate research to enhance scientific understanding and assessment of effects.
2. The state should provide financial and technical assistance for feasibility studies and evaluations that could lead to enhanced management of water resources through system reoperation. Give priority for funding and technical assistance to system reoperation projects with multiple benefits.
3. The state should continue to study the potential impacts of global climate change on water management in California and develop potential strategies to respond to these impacts.
4. Operators of all projects should improve runoff forecasting and decision support systems for reservoir reoperation to manage water resources among competing demands.
5. The state should support research in improving our understanding of flow alteration effects on aquatic ecosystems as well as develop management tools to address these effects.

Information Sources

- California Energy Commission, Integrated Energy Policy Report Workshop, "Hydropower System – Energy and Environment". June 5, 2003
- El Dorado Irrigation District (EID 2003a), The Water Front, May – June 2003
- EID 2003b, FERC Economic Analysis Critique – El Dorado Hydroelectric Project, Prepared for EID by Mead & Hunt, April 2003
- EID 2003c, Operational Modeling Prepared by Hydrologics for EID, April 2003
- Kessler, John S., personal communication. Kessler and Associates, LLC, August 2003
- California State Water Resources Control Board. Draft California Nonpoint Source Program Five-Year Implementation Plan July 2003 Through June 2008. July 2003

Urban Land Use Management

Urban land use management consists of planning for better urban land use decisions that provide efficient use of water and other resources. The way in which we use land — the types of use and the level of intensity — has a direct relationship to water supply and quality.

Current Urban Land Use Patterns in California

Traditional urban development patterns are often characterized by fragmented and segregated land uses, low density residential and strip commercial development, and a lack of connectivity within and between neighborhoods that can consume large quantities of land per capita. The result is the consumption of more prime farmland, open space, habitat, and an increased impact on other natural resources. These traditional development patterns rely primarily on the automobile to connect jobs, services, and community amenities. Transportation alternatives such as walking, biking, and public transportation are often unsafe, ineffective, or not economically feasible. The creation of large amounts of impervious surfaces, such as roads and parking lots, results in the degradation of water quality by causing more rapid and larger amounts of surface runoff. This change in runoff also alters stream flow and watershed hydrology, reduces groundwater recharge, increases stream sedimentation, and increases the need for infrastructure to control storm runoff.

Growth can be managed to improve our communities. In some of the most densely populated regions of the state, including the San Francisco Bay Area and Los Angeles, headway is being made to grow more compactly, provide jobs close to housing, provide transit to connect people with community resources and opportunities, and to mix land uses for a more vibrant social fabric. California law (Government Code § 65041.1-65042) establishes three state planning priorities that encourage a new development pattern for the state. These priorities organize state capital and infrastructure investments around:

1. Infill development
2. Protection of environmental and agricultural resources
3. Compact development that is contiguous to existing development and infrastructure

These statutorily mandated land use planning principles recognize the need for state agencies to coordinate their actions. Proposed state capital improvements will not be included in the state's five-year infrastructure plan until they are consistent with the planning priorities. This will indirectly, but powerfully influence local land use decisions.

Local Agency Formation Commissions (LAFCOs) are regional planning agencies that were established to encourage logical and efficient development patterns. With the recent changes to Government Code § 56000 et. seq., LAFCOs are now required to perform municipal service reviews on a regular basis. This will allow a comprehensive evaluation of how all services, including water, are delivered to developing areas of the state.

Potential Benefits from Resource Efficient Development

Development patterns that regionally integrate transportation, parks, open space, schools, energy, housing, water, sewage, and garbage collection can result in multiple benefits not realized by traditional development patterns. Regionally resource efficient development patterns use existing infrastructure and compact development that supports walking, biking, and public transit. It encourages a mix of land uses and a balance of jobs and housing both of which reduce miles and time spent in automobiles. There are numerous water-related benefits that accrue from resource efficient development. It requires less water and minimizes pollution of our surface and groundwater. Also, by focusing on infill and compact development, impacts to habitat, watershed functions, and groundwater recharge areas are reduced.

Experience from Other States

Studies in New Jersey and South Carolina found that when compact development, that encourages open space, was compared to traditional development patterns, compact development reduced the amount of runoff and pollution. In the New Jersey study, the compact development pattern reduced pollution from 10 percent for lead, to 40 percent for nitrogen and phosphorus over a 20-year period. The study also found that compact development reduced water and wastewater infrastructure costs because demand was decreased and less physical infrastructure was needed. In South Carolina, a compact town development model produced 43 percent less runoff than a traditional development model.

Compact, mixed-use development can reduce water demand, even with moderate increases in density. As a rule of thumb, landscaping irrigation accounts for almost half of residential water usage. An increase in residential density from four units per acre to five reduces the landscaping area by 20 percent, which should cut water usage by roughly 10 percent compared to the lower density development.
A smaller urban footprint reduces impervious surfaces. This generates less surface runoff and sediment load, and minimizes intrusion into watersheds and groundwater recharge areas which receive the runoff and sediment. Less interference with natural systems can also reduce the frequency and severity of flood events.

Potential Costs

Cost savings may result from reduced costs to treat and store surface runoff. There may also be a reduction in costs related to flood protection. Resource efficient development requires less infrastructure expansion to increase water supply, and lower mitigation costs for development impacts on agricultural land and wildlife habitat.

There will be new costs associated with changing the way local, regional, and state agencies plan our urban areas. Among these are costs for increased communication and coordination between land use agencies, water suppliers, and agencies which regulate water quality. Increased coordination among all levels of government will be necessary to coordinate inter-agency planning efforts, to develop information databases, and to interpret and share data and information.

State and local development codes, including zoning ordinances and building codes, may need to be changed to facilitate a more resource efficient development model. There may be costs to educate the public, decision makers, and the development community about the benefits of resource efficient development. Funding institutions, including state government agencies, may need to target water quality and water supply funding programs to encourage infill and compact development.

Infill development often requires the upgrading of existing infrastructure to increase its capacity. These infrastructure costs may be offset in the long run buy avoiding the costs of infrastructure and municipal service expansion that traditional development patterns require. Most of the costs associated with using a resource efficient development pattern seem to be short-term, while the cost savings are more long-term.

Major Issues

Disincentives for Change

Local governments make most of the land use decisions in California. There are many reasons why local governments do not use more resource efficient development patterns including: community resistance to infill or higher density development, institutional biases in local zoning ordinances which have not been updated for many years, the added cost to conduct regional planning efforts, the cost and liability associated with pursuing infill projects, and traditional environmental mitigation strategies that encourage lower density development.

Coordination

Recent changes to the Government Code and the Water Code requires local governments to determine whether there will be enough water to supply a proposed development project before it can be approved. This will require land use agencies and water agencies to communicate and coordinate on project-level development decisions that have been made independently in the past.

Recommendations

State

1. All state agencies that influence or affect land use development or infrastructure development must update their strategic and functional plans to be consistent with the three state planning priorities by Jan. 1, 2005. Funding requests for infrastructure or capital improvements also must be consistent with the three state planning priorities as of Jan. 1, 2005, to be included in the state's five-year infrastructure plan.
2. Provide incentives to developers and local governments to plan and build using more resource efficient development patterns. This can be done through prioritizing planning and infrastructure grants to encourage infill and compact development forms.
3. Encourage local governments to adopt a water element in their general plans or otherwise show compliance with recent changes to the Government Code and the Water Code, which requires local governments to determine whether there will be enough water to supply a proposed development project before it can be approved.
4. Provide technical assistance to local governments on how to incorporate resource efficient development into their local general plan, related zoning ordinances, and specific plans and how to prepare required water supply assessments before approving major new development projects.
5. Develop and publicize accurate and relevant data on water supply and water quality to help local agencies in their planning efforts.
6. Encourage more research on the impacts of resource efficient development patterns and best practices.

Local Government

1. Recognize regional needs and resources when designing and building neighborhoods and communities. Coordinate with other local agencies, regional planning agencies, and local water agencies and watershed managers.
2. Promote the rehabilitation of aging or inadequate infrastructure to help infill development.
3. Direct new development away from prime agricultural land, open space, flood plains, recharge areas and wetlands to areas where there is existing infrastructure.
4. Encourage less water-intensive landscaping.

5. Reduce the amount of impervious surfaces used in development especially near waterways.

Regional Government

1. LAFCOs, councils of governments, and watershed planning organizations should participate in the development of local general plans by offering policy recommendations that are supported by data and information.
2. LAFCOs should consider water supply and water quality issues in the context of their charge to encourage logical and efficient development patterns that minimize impacts on agricultural land and maximize housing affordability.

Water Suppliers

1. Develop and make available water resource information, such as water supply and water quality, to local governments that can be used in local and regional land use decisions, including general plan formulation and municipal service reviews.
2. Collaborate on assessing water supply availability for new development.

Information Sources

- Governor's Office of Planning and Research, Environmental Goals and Policy Report, November 2003.

Urban Runoff Management

Urban runoff management is a broad series of activities to manage both stormwater and dry weather runoff. Dry weather runoff occurs when, for example, excess landscape irrigation water flows to the storm drain. Urban runoff management is linked to several other resource strategies including pollution prevention, land use management, watershed management, water use efficiency, recycled water, protecting recharge areas, and conjunctive management. Traditionally, urban runoff management was viewed as a response to flood control concerns resulting from the effects of urbanization. Concerns about the water quality impacts of urban runoff have led water agencies to look at watershed approaches to control runoff and provide other benefits.

Objectives of Urban Runoff Management

- Protection and restoration of surface waters by the minimization of pollutant loadings and negative impacts resulting from urbanization
- Protection of environmental quality and social well-being
- Protection of natural resources, e.g., wetlands and other important aquatic and terrestrial ecosystems
- Minimization of soil erosion and sedimentation problems
- Maintenance of the predevelopment hydrologic conditions
- Protection of groundwater resources
- Control and management of runoff to reduce or prevent flooding
- Management of aquatic and riparian resources for active and passive pollution control

Current Urban Runoff Management

With the traditional approach to runoff management, urban runoff is viewed as a flood management problem where water needs to be conveyed as quickly as possible from urban areas to waterways to get rid of it. Urbanization alters flow pathways, water storage, pollutant levels, rates of evaporation, groundwater recharge and surface runoff, the timing and extent of flooding, the sediment yield of rivers, and the suitability and viability of aquatic habitats. The traditional approach has been successful at preventing flood damage, but has several disadvantages. In order to convey water quickly, natural waterways are often straightened and lined with concrete, resulting in a loss of habitat, a reduction in groundwater recharge from streams, and impacts to natural stream physical and biological processes. This collects pollutants and increases runoff volume and speeds its flow, resulting in pollution, stream bank erosion, and potentially flooding problems downstream. Because of the emphasis on removing the water quickly, the opportunity to use water for multiple benefits is reduced.

The watershed approach for urban runoff management tries to emulate and preserve the natural hydrologic cycle that is altered by urbanization. The watershed approach consists of a series of best management practices (BMPs) designed to reduce the pollutant load, volume of urban runoff reaching waterways, and slow its flow. These BMPs may include requiring new facilities to capture, treat, and recharge groundwater with urban runoff, conducting public education campaigns for the proper use and disposal of household chemicals, and providing technical assistance and storm water pollution prevention training. Some areas advocate collecting rainfall from roofs into cisterns for later use as supply. Methods for recharging groundwater with urban runoff include draining runoff from parking lots, driveways, and walkways into landscape areas with permeable soils, using drywells, and using permeable surfaces. These BMPs may include source control and pretreatment before infiltration. Infiltration enables the soil to naturally filter many of the pollutants found in runoff and reduces the volume and pollutant load of the remaining water when it reaches the outfall. The watershed strategy will not prevent all urban runoff from entering waterways, so elements of the traditional conveyance and storage strategy will still be needed.

Examples of Nonpoint Source Pollution

- Herbicides and insecticides from residential landscaped areas, golf courses, city parks, etc.
- Oil, grease, and heavy metals illegally/improperly disposed of or accumulated on parking lots, streets and highways from automobiles, trucks, and busses
- Sediment from improperly managed construction activities
- Litter and green wastes
- Bacteria and nutrients from excess fertilizers, improperly maintained septic systems, and wastes from pets and wildlife

Urban runoff management has become more important and controversial over the last decade as municipal governments have been held increasingly responsible for nonpoint source pollutants washed into waterways from developed areas within their jurisdictions. Nonpoint source pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. Nonpoint source pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and potentially into groundwater. Nonpoint source pollution also occurs from non-storm event activities, such as aerial deposition, dry weather flows from landscape irrigation, improper disposal of trash or yard waste, and leaky septic systems.

The 1987 amendments to the federal Clean Water Act directed the U.S. Environmental Protection Agency (USEPA) to establish a permitting system under the National Pollutant Discharge Elimination System (NPDES) to regulate nonpoint source pollution from certain urban areas in order to protect water quality. In California, the authority to regulate urban and stormwater runoff under the NPDES system has been delegated by USEPA to the State Water Resources Control Board (SWRCB) and the nine Regional Water Quality Control Boards (RWQCBs). The State of California is required under Clean Water Act (CWA) section 303(d) and federal regulations (40 CFR 130) to prepare a list of and set priorities for waterways requiring Total Maximum Daily Loads (TMDLs) because they do not meet water quality standards. The section 303(d) list was last revised in 2002. Federal regulations require the section 303(d) list to be updated every two years. TMDLs represent the total pollutant load a waterway can assimilate before the waterway's beneficial uses are impacted. Nonpoint source runoff is frequently a significant source of pollutants in a waterway's total pollutant loading.

Because municipal governments are responsible for controlling urban runoff from streets and other public facilities within their jurisdictions, they are required to obtain an NPDES permit and implement specific measures to reduce the amount of pollutants in urban runoff. Permits for discharge to listed waterways having a TMDL must be consistent with the load assignments in a TMDL. Under California law TMDLs include implementation plans for meeting water quality standards. The implementation plans allow for time to implement control strategies to meet water quality standards. Under the initial NPDES permits issued in the 1990's municipalities were required to establish land use and development guidelines for both new and existing development to reduce the discharge of pollutants into waterways. These guidelines are usually a series of BMPs as described above. It has become clear with continued beach closures and other pollution problems associated with urban runoff that more advanced measures will be required in some areas to comply with water quality regulations.

Potential Benefits of Urban Runoff Management

The primary benefits from urban runoff management are to reduce nonpoint source water pollution and improve flood protection. Additional benefits may be to increase water supply through groundwater recharge in areas with suitable soil and geological conditions, and improve wildlife habitat, parks and open space. Groundwater recharge and stormwater retention facilities can be designed to provide additional benefits to wildlife habitat, parks, and open space. Underground infiltration galleries can temporarily store runoff and release it gradually to the aquifer while allowing the unimpaired use of the surfaces above them. For instance, a school campus can solve its flooding problem and develop a new sports field at the same time. These may provide secondary benefits to the local economy by creating more desirable communities in which to live. By keeping runoff onsite, storm drain systems can be downsized, reducing installation and maintenance costs of such systems. A watershed planning approach to manage urban runoff allows communities to pool economic resources and obtain broader benefits to water supply, flood control, water quality, open space, and the environment. Properly implementing this approach will require unconventional partnerships between different disciplines.

Five Year Implementation Plan for Nonpoint Source Pollution Program

The SWRCB and the California Coastal Commission in coordination with 26 other State agencies are finalizing the Five Year Implementation Plan for the Nonpoint Source Pollution Program, which includes management of urban runoff. The Implementation Plan recommends the following State actions:

- Promote coordination of interagency programs that protect water quality from urban runoff pollution.
- Reduce the potential for contamination of surface and groundwater that results from uncontrolled or poorly-controlled urban runoff practices.
- Develop tools to assess the effectiveness of urban water pollution programs.
- Increase the availability of regulatory and guidance documents and/or instructional workshops to demonstrate effective urban runoff pollution control programs and policies.
- Reduce the number of uncontrolled urban NPS pollution sources by increasing the number of municipalities, industries and construction sites that utilize NPS management measures and fit under the permitted State Storm Water Program.
- Develop and implement watershed-based plans, including TMDLs and Storm Water Pollution Prevention Plans (SWPPPs), in order to identify and address impacts from urban land use.

Statewide information on the benefits of increased management of urban runoff is not available, although examples from local efforts exist. The Fresno-Clovis metropolitan area has built an extensive network of storm water retention basins that not only recharges over 70 percent of the annual storm water runoff (17,000 acre feet) and removes a majority of conventional storm water pollutants, but also recharges excess entitlement water (Sierra snow melt) during the late spring and summer (27,000 acre feet). Los Angeles County recharges on average 210,000 acre-feet storm runoff a year, which reduces the need for expensive imported water. Agencies in the Santa Ana Watershed recharge approximately 78,000 acre-feet of local storm runoff a year. The Los Angeles and San Gabriel Watershed Council has estimated that if 80 percent of the rainfall that falls on just a quarter of the urban area within the watershed (15 percent of the total watershed) was captured and reused, total runoff would be reduced by approximately 30 percent. That translates into a new supply of 132,000 acre-feet of water per year or enough to supply 800,000 people for a year.

The City of Santa Monica is an example of a municipality that is taking a watershed approach to managing urban runoff. Santa Monica's primary goal is to treat and reuse all urban runoff. This turns a perceived waste product into a local water resource. Not only is water quality achieved, but a new water resource is harvested. This decreases the dependence on imported water, leaving this water supply in distant watersheds for uses there, especially in the case of Southern California where most of its water comes from Northern California rivers, Eastern Sierra snow melt and Colorado River. If necessary, because of high runoff, the City's secondary goal is to release only treated runoff into waterways. Both goals improve water quality of the Santa Monica Bay. The City's goals promote low impact development and smart growth, two similar approaches to land use, in which urbanization works with nature and the hydrologic cycle.

Potential Costs of Urban Runoff Management

Information is not available on statewide costs to implement urban runoff management activities; however, the State Water Resources Control Board has recently contracted with the Office of Water Programs, California State University at Sacramento, to survey six communities to estimate the municipalities' costs to complying with their NPDES storm water permits. While this may address the cost for a municipality to comply with an NPDES permit, it may not be the most applicable for looking at watershed programs seeking multiple benefits.

An example from the City of Santa Monica illustrates the costs of the watershed approach to managing urban runoff. The City has a stormwater utility fee that generates about $1.2 million annually, and has been in place since 1995. These funds are used for various programs to reduce or treat runoff. These funds go to the Urban Runoff Management Coordinator, the maintenance of the storm drain system, and help support other City staffs that perform supportive runoff work. Additional funds are spent by other divisions to support runoff management, such street sweeping, certain trash collection, sidewalk cleaning, and purchase and maintenance of equipment. The City has also received five grants totaling over $3.5 million for the installation of structural BMP systems, all of which will require long-term maintenance and monitoring by the City. The culmination of the City's program is the $12 million Santa Monica Urban Runoff Recycling Facility (SMURRF), a joint project of the cities of Santa Monica and Los Angeles. The SMURFF project is a state-of-the-art facility that treats dry weather runoff water before it reaches Santa Monica Bay. Up to 500,000 gallons per day of urban runoff generated in parts of the cities of Santa Monica and Los Angeles can be treated by conventional and advanced treatment systems at the SMURRF.

Major Issues

Lack of Integration with Other Resource Management Strategies

A major problem is that land use planning is not conducted on a watershed wide basis. Many agencies currently spend millions of dollars annually on addressing urban runoff problems with very little interagency coordination even though downstream cities can be impacted by activities upstream. Solutions to managing urban runoff are closely tied to many interrelated resource management strategies including land use planning, watershed planning, water use efficiency, recycled water, protecting recharge areas, and conjunctive management.

Lack of Funding

The two main aspects of implementing urban runoff management measures are source control, including education, and structural controls. In highly urbanized areas, major costs include purchasing land for facilities and constructing treatment facilities. Local municipalities have limited ability to pay for retrofitting existing developed areas within existing budgets and there is a concern by some about the economic impacts of raising taxes and requiring residents and businesses to pay for retrofitting existing development.

Effects of Urban Runoff on Groundwater Quality

The movement of pollutants in urban runoff is a concern. Urban runoff contains chemical constituents and pathogenic indicator organisms that could impair water quality. The actual threat to groundwater quality from recharging urban runoff is dependent on several factors, including soil type, source control, pre-treatment, solubility of pollutants, maintenance of recharge basins, and depth to groundwater. Studies by USEPA (USEPA, 1983) and the U.S. Geological Survey (USGS, 1995) indicate that all monitored pollutants stayed within the first 16 centimeters of the soil in the recharge basins.

Nuisance Problems

Presence of standing water in recharge basins can lead to vector problems, such as mosquitoes and increasing concern related to the transmission of West Nile Virus. ***Protecting Recharge Areas*** – Local land use plans often do not recognize and protect groundwater recharge and discharge areas. Areas with soil and geologic conditions that allow groundwater recharge should be protected where appropriate.

Understanding

The general public and elected officials don’t always understand about the linkage between land use management and other resource management strategies and how home and business practices can affect nonpoint source pollution in water ways.

Recommendations to Promote Additional Urban Runoff Management

State

1. State agencies should coordinate their efforts to decide how the Five Year Implementation Plan for Nonpoint Source Pollution Program should be integrated into their workplans.
2. Encourage public outreach and education about the benefits and concerns related to funding and implementation of urban runoff measures.
3. Provide leadership in the integration of water management activities by assisting, guiding, and modeling watershed and urban runoff projects.
4. Work with local government agencies to evaluate and develop ways to improve existing codes and ordinances that currently stand as a barrier to implementing and funding urban runoff management.
5. Provide funding and develop legislation to support development of urban runoff and watershed management plans and enable local agencies and organizations to pursue joint venture, multi-purpose projects.
6. Assist agencies with developing recharge programs with appropriate measures to protect human health, the environment, and groundwater quality.
7. Work with federal policy makers and industry to create research and development incentives and to develop standards to reduce nonpoint source pollution from transportation related sources including lubricant systems, cooling systems, brake systems, tires, and coatings.

Local Agencies and Governments

1. Local agencies and governments should design recharge basins to minimize physical, chemical, or biological clogging, periodically excavate recharge basins when needed to maintain infiltration capacity, develop a groundwater management plan with objectives for protecting both the available quantity and quality of groundwater, and cooperate with vector control agencies to ensure the proper mosquito control mechanisms and maintenance practices are being followed.
2. When developing Urban Runoff Management Plans, local agencies and governments should:
   - Understand how land use affects urban runoff.
   - Look for opportunities to require features that conserve, clean up, and reduce urban runoff in new development, or in more established areas, when redevelopment is proposed.
   - Be aware of technological advances in products and programs.
   - Learn about urban runoff / watershed ordinances already in place. For example, The City of Santa Monica and the Fresno Metropolitan Flood Control District already have extensive urban runoff management programs in place.
   - Integrate urban runoff management with other resource strategies including land use planning, watershed planning, water use efficiency, recycled water, protecting recharge areas, and conjunctive management, and coordinate both within and across municipal boundaries.

Information Sources

- California State University at Sacramento, University of California, Davis, and California Department of Transportation. “Caltrans Stormwater Management Program”. Stormwater Journal. March/April 2001.
- California State Water Resources Control Board. Draft Statewide Urban Nonpoint Source Pollution Implementation Plan. 2003.
- City of Santa Monica, “Stormwater Best Management Practices for New Developments”. Brochure.
- City of Santa Monica, “Working for a Cleaner Bay”. Brochure.
- Dallman, Suzanne and Piechota, Thomas. “Stormwater: Asset not Liability”. Los Angeles and San Gabriel Rivers Watershed Council. 2000.
- Hildebrand, Gary. Los Angeles County, Department of Public Works. Personal Communication. May 2003.
- Pitt, R. et al., “Potential Groundwater Contamination from Intentional and Nonintentional Stormwater Infiltration”. US EPA, Office Research and Development, EPA/600/R-94-051.
- Rourke, Daniel. Fresno Metropolitan Flood Control District. Personal Communication. August 2003.
- Santa Ana Watershed Project Authority, “Santa Ana Integrated Watershed Plan”. June 2002.
- Shapiro, Neal. City of Santa Monica. Personal Communication. August 2003.
- United States Environmental Protection Agency, ”Results of the Nationwide Urban Runoff Program – Final Report”. US EPA Water Planning Division. 1983.
- United States Geological Survey, “Potential for Chemical Transport Beneath a Storm-Runoff Recharge (Retention) Basin for an Industrial Catchment in Fresno, California”. USGS. Water Resources Investigations Report 93-4140. 1995.

Urban Water Use Efficiency

Urban water use efficiency efforts involve technological or behavioral improvements in indoor and outdoor residential, commercial, industrial and institutional water use that lower demand, lower per capita water use, and result in benefits to water supply, water quality, and the environment.

Current Urban Water Use Efficiency Efforts in California

The urban sector applied about 8.7 million acre-feet of water in 2000. Californians have made great progress toward improved urban water use efficiency over the last few decades. For example, the Los Angeles Department of Water and Power reports in their Urban Water Management Plan Update 2002-2003 that "water conservation continues to play an important part in keeping the City's water use equivalent to levels seen 20 years ago." While some other regions of the state cannot claim such progress, these reports indicate that indeed something is working well in the field of water use efficiency. As has been demonstrated in various regions of the state, an increase in population does not necessarily result in a proportionate increase in urban water use.

Credit for these improvements can be given in part to the implementation of water use efficiency practices that have been institutionalized through the California Urban Water Conservation Council's (CUWCC) Memorandum of Understanding (MOU). This involves the active participation and united effort of urban water agencies, environmental interests, and the business community. They come together to plan, implement, and track a defined set of urban Best Management Practices (BMPs) including residential indoor and outdoor water use surveys and improvements; commercial, industrial, and institutional water use audits and plumbing retrofits, landscape irrigation audits and upgrades; district water system leak detection and repair programs; metering, washing machine incentive programs, conservation pricing, waste water reduction ordinances, and public information and education programs. As of Sept. 1, 2003, there were 309 signatories to the Urban MOU, representing 80 percent of all the urban water supplied in California.

Urban BMPs

BMP 1: Residential Survey Programs

BMP 2: Residential Plumbing Retrofit

BMP 3: System Water Audits

BMP 4: Metering w/Commodity Rates

BMP 5 Large Landscape Conservation

BMP 6: High Efficiency Clothes Washers

BMP 7: Public Information Programs

BMP 8: School Education Programs

BMP 9: Commercial Industrial Institutional

BMP 10: Wholesaler Agency Assistance Programs

BMP 11: Conservation Pricing

BMP 12: Conservation Coordinator

BMP 13: Water Waste Prohibitions

BMP 14: Residential Ultra Low Flush Toilet Replacement Programs

One example of the results of the CUWCC's member agency implementation efforts is that 2.3 million water efficient toilets have been retrofitted statewide in the past 12 years. The total number of toilets installed before 1992 that still need to be replaced is about 10 million. Water conservation has become a way of life for Californians, most of whom have easy and affordable access to a wide array of off-the-shelf water efficient plumbing fixtures, washing machines, landscape irrigation systems, and water-thrifty plants at there local home improvement stores, hardware stores, and nurseries. While the council is considering more BMPs, there are other activities that could contribute toward improved water use efficiency, including new methods and technologies that can be expected to significantly increase conservation potential.

Potential Benefits of Urban Water Use Efficiency

The primary benefit of improving water use efficiency is the lowering of demand and the ability to cost-effectively stretch existing water supplies. Once viewed and invoked primarily as a temporary source of water supply in response to drought or emergency water shortage situations, water use efficiency and conservation approaches have become a viable long-term supply option, saving considerable capital and operating costs for utilities and consumers, avoiding environmental degradation, and creating multiple benefits for all sectors.

The financial benefits to agencies of water use efficiency are the avoided costs of new supply construction and the avoided costs of water supply treatment and wastewater treatment plant permitting, construction and operation. Energy costs, which are often much greater than water costs, are avoided as well, both by the agency and the customer.

The multiple benefits of urban water use efficiency include the positive impacts on water quality and water quantity in watercourses by allowing more flows to remain in the environment. The timing of such additional flow is often critical to maintenance of endangered habitats. Water use efficiency can also reduce peak demand, green waste production, and urban dry weather runoff.

The range of net water savings of existing urban water use efficiency efforts by 2030 has been estimated to be 1.085 million to 1.335 million acre-feet per year (CALFED Record of Decision, 2000). A recent state-sponsored study (Pacific Institute's "Waste Not, Want Not") indicates potential savings of 2 to 2.3 million acre-feet per year. DWR and California Bay-Delta Authority are employing new methodologies to estimate the urban water savings potential for 2030. The new estimates will be included in the Administrative Draft.

Potential Costs of Urban Water Use Efficiency

Overall, urban water use efficiency can be a very cost-effective strategy for new water supply. The cost of most of these measures ranges from $29 to $700 per acre-foot, depending upon the program (per CUWCC). These costs include not only the full cost to manage water conservation programs, but also any capital investments and staffing that may be required. In fact, water conservation measures that also include reductions in energy costs can produce net savings when those benefits to the agency and customer exceed the costs. Implementation of other measures beyond the BMPs may also be cost-effective.

Major Issues Facing Additional Urban Water Use Efficiency

The major issues related to improving urban water use efficiency in California are related to funding, program implementation, data collection, education and motivation, innovation, and dry year considerations.

Funding

Funds dedicated to water use efficiency have fallen below commitments made in 2000 through the CALFED Record of Decision that called for a state and federal investment of $1.5 billion to $2 billion during Stage 1 from 2000-2007. For example, by 2002, investments lagged projected expenditures by only $4 million. By 2003, investments lagged projected expenditures by $235 million.

Presently, through the CUWCC MOU, local agencies have committed to funding locally cost effective BMPs. On an erratic basis, state and federal programs provide funding for the BMPs beyond the MOU level for actions other than standard BMPs, and for those BMPs that may not be locally cost effective. Developing a consistent and broadly acceptable method to evaluate cost-effectiveness and water savings can be problematic.

While the initiatives have provided state bond funding for water use efficiency projects through Propositions 13 and 50, retaining sufficient state and federal expertise to administer the programs and provide financial and technical assistance in this field is not easy with budget and staff cutbacks. Local agencies also face increasing challenges to implement water use efficiency actions with limited staff and budgets.

Grant programs often miss the opportunity to fund worthwhile projects in small and disadvantaged communities. It is often difficult for them to compete for limited grant funds, although their needs are often great. Also, investor-owned utilities have been ineligible for state funding for most programs.

Program Implementation

An expanding population, climatic uncertainties, contaminants, and legal and economic conditions likely will increase the pressure to improve the efficiency of water use in California. While the CUWCC Best Management Practices have provided an effective way for agencies to identify and implement locally cost effective urban water conservation programs, not all water suppliers have signed on to the agreement and not all of the signatories are fully implementing those practices.

Data Collection

Documentation and evaluation of the achievements attributable to water use efficiency projects and programs, vital elements of successful water use efficiency efforts, need to be improved. The quantification of benefits for many projects lacks the necessary level of scientific rigor. The basis for making such determinations and managing water efficiently is accurate water measurement, coupled with volumetric billing, complemented by ongoing accounting, monitoring and assessment practices.

The measurement of water use and associated information provided to the water user are essential to efficient water management. Documenting water savings related to the various programs rests on the ability to track water use. Most urban areas are metered, but several metropolitan areas, mostly in the Central Valley and Foothill regions, remain unmetered. About 700,000 water users remain unmetered.

Easily retrievable, standardized and comprehensive baseline data about California urban water use are not available. Present information sources include annual Public Water System Survey (PWSS) reports to DWR, annual CUWCC BMP Reports submitted by MOU signatories only, and Urban Water Management Plans that are updated every five years. Efforts are ongoing to standardize units of measurement for water use categories. Both of these endeavors are necessary to gain an accurate understanding of the full cost, value, impact and direction of urban water use efficiency strategies.

More information is needed about how Californians use water to help determine how scarce resources should be invested to maximize water savings and other benefits. How many acres of irrigated landscape? What is the breakdown between indoor and outdoor water use, between single-family and multifamily residences?

Education and Motivation

Likewise, there is a need for information related to why Californians adopted water use efficiency practices and how those practices could be encouraged and sustained. Also, we are not sure what types of incentives customers or water districts respond best to, while we have seen evidence of a strong response to financial incentives whenever offered in a simple, understandable format and process. Which technological changes should be pursued for short-term situations (during water shortages) compared to long-term, and which behavioral changes are most effective short and long term?

Demand Hardening

Most water use efficiency programs rely on plumbing and appliance retrofits and changes in the consumer's water use that can take place on a consistent, predictable basis. Once most of these retrofits have been completed, some worry that their ability to further reduce water use during dry years will be limited. This phenomenon is known as 'demand hardening'. Districts and customers that have participated actively in water conservation programs fear that across-the-board cuts will affect them disproportionately. However, consumers will still respond behaviorally in drought times, and this additional water savings from the drought response can be measured. Public education has proven effective in rallying support for short-term additional water conservation measures.

Innovation

Emerging water conservation technologies and techniques offer new opportunities to save water, but often field-testing and evaluations are needed before being promoted and adopted full scale. Presently it takes too long to run pilot projects, conduct research, and provide the sound scientific data needed by agencies and consumers to adopt new behaviors or purchase new equipment.

Recommendations to Achieve Additional Urban Water Use Efficiency

In addition to the BMPs, the following actions reflect some of the possible solutions to the issues raised in the previous section. A wide range of strategies will need to be employed to accomplish the actions including financial incentives; revisions in state and local codes and standards; and legislative initiatives. Most of these will be cooperative efforts, involving state, federal, and local agencies and stakeholders and California citizens.

1. The state should secure funding to support incentive programs, both implementation and data quantification, and associated expertise at the local level and at the state and federal levels. Identify and establish priorities for future grant programs and other incentives. Provide ample opportunities for small districts, economically disadvantaged communities, and investor owned utilities to benefit from WUE incentive programs.
2. Work with CUWCC and others to encourage and help local agencies and governments in fully developing, implementing and sustaining water conservation programs. Develop and implement rate structures that encourage water use efficiency. Help water customers perform leak detection and repair on a regular basis. Employ recycled water whenever feasible for landscape, industrial, and other approved uses. Encourage the plumbing of new construction for the use of non-potable water.
3. The state should provide technical assistance to create "California Friendly Landscapes," those that attain maximum water use efficiency by applying the minimum amount of water necessary to sustain

them. Consider how to irrigate landscapes efficiently through landscape design, installation, management and maintenance practices including plant selection, irrigation scheduling, landscape audits, dedicated irrigation meters, weather driven timers, etc. Consider use of graywater systems where conditions permit and cistern systems to capture storm water where appropriate.

4. Develop collaborative efforts to:
   - Work with builders, manufacturers and others to establish a “Water Star Homes” program for new and existing homes and performance standards for fixtures and appliances, reducing residential water use.
   - Retrofit remaining standard toilets with more efficient models, such as dual-flush toilets or 1.0 gallon-per-flush toilets.
   - Employ hot water on demand systems in new residential construction.
   - Pursue best available technology and management practices in the commercial, industrial, and institutional sector.
   - Retrofit standard urinals with more efficient models.
   - Encourage the formation of employee/management “Green Teams” in commercial, industrial and institutional customers to promote sustainable resource use.
   - Encourage dry cooling for power plants.
   - Provide comprehensive public information, education, training, and technical assistance programs to foster a strong environmental resource ethic with an emphasis on water use efficiency.
   - Coordinate with other resource management programs such as watershed management, urban runoff management, waste water treatment, and green waste reduction.
5. Consider data, research and monitor needs to inform decisions on:
   - Meter remaining urban customers and bill by volume of use, submeter new multifamily residential construction, and submeter large landscape irrigation.
   - Employ scientific methods to research, monitor, and evaluate existing and new water use efficiency technologies and management practices, including the positive and potentially negative effects of these practices and real world challenges to implementation.
   - Increase the emphasis on the science aspect of projects, especially monitoring and evaluation, in support of CALFED goals.
   - Work with state and federal grant recipients and others to obtain more useful and consistent data from funded projects and other activities, including the documentation of the sources of data and the methods of data collection.
   - Encourage comprehensive planning and implementation of water conservation activities at the local and regional level. Pursue and promote state or local policies, guidelines, ordinances, or regulations to affect positive change.
   - Encourage more signatories to the CUWCC Memorandum of Understanding and full participation by present signatories.
   - With the leadership of the CUWCC and participation of other stakeholders, standardize utility billing and reporting systems by customer type and units of measure and identify industrial water use customers by North American Industry Classification System (NAICS). Collect end-use data periodically. Coordination of water use reports and the use of a web-based format for reporting could also improve data collection and exchange. Amend the Urban Water Management Planning Act to require uniform water use reporting.

- Gain more information through surveys and other methods to better understand how Californians use water and how to persuade them to adopt more efficient practices and behaviors. Establish a goal for per capita water use in California.

6. Develop community based social marketing surveys and strategies for conservation activities to foster water use efficiency, with the participation of the water industry, environmental interests, and the business communities. Identify and overcome barriers, communicate the benefits, provide incentives, and gain commitment from all involved.
7. Explore and identify innovative technologies and techniques to improve water use efficiency and develop new BMPs to correspond with new information. Fast track pilot projects, demonstrations, and model programs exploring state-of-the-art, water-saving technologies and procedures and publicize results widely.

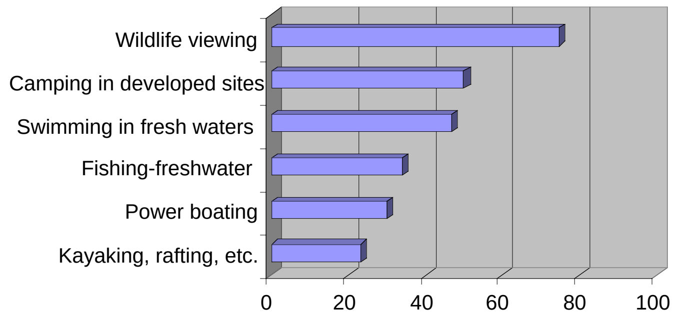
Information Sources

- Los Angeles Department of Water and Power. "Urban Water Management Plan Update 2002-2003".
- California Urban Water Conservation Council. Mary Ann Dickinson, Executive Director. September, 2003.
- CALFED Bay-Delta Authority. "CALFED Record of Decision". July, 2000.
- Pacific Institute. *Peter H. Gleick, Dana Haasz, Christine Henges-Jeck, Veena Srinivasan, Gary Wolff, Katherine Kao Cushing, Adardip Mann*. "Waste Not, Want Not: The Potential for Urban Water Conservation in California". November, 2003.
- Department of Water Resources. Marsha Prillwitz, Chief, Office of Water Use Efficiency. January, 2003.
- Department of Water Resources. Staff estimate, Office of Water Use Efficiency. March, 2003.

Water-Dependent Recreation

Water-dependent recreation includes a wide variety of outdoor activities that can be divided into two categories. The first category includes fishing, boating, swimming, rafting and other activities that can only occur on water surfaces such as fresh-water lakes, reservoirs, and rivers. The second category includes those outdoor recreation activities where the experience sought and the aesthetic appeal are greatly enhanced by the presence of water features but do not necessarily require actual use of the water resource. These activities are often nature-based and include wildlife viewing, picnicking, camping and hiking.

Figure 1: Percentage of Californians Participating in these Water-Dependent activities



Data source: "Public Opinions and Attitudes on Outdoor Recreation in California 2002"

Water-dependent recreation is included among the water management strategies because recreation is an important consideration for water managers. Water management, and water infrastructure, can have significant effects on recreational opportunities. By considering recreation during the planning process, water managers can take advantage of opportunities to enhance recreation, and can guard against actions that would impair or limit recreation.

The Davis-Dolwig Act was passed by the California Legislature in 1961. This act established state policy regarding recreation and fish and wildlife enhancement at state-built water facilities, and specified the responsibilities of state agencies under the act. Compliance with the provisions of this act will be an important consideration for state water managers as new facilities are built.

The management of lands and water resources by the state, including those associated with state water projects, invokes an implied principle of trust responsibility. State agencies managing lands and water resources are required to uphold public trust in the planning, management, use and protection of resource values. As trustee to public resources, the state must consider the benefit and use of land and water resources for recreational opportunities for current and future Californians. As discussed in Chapter 2 of Volume 1, the Public Trust Doctrine recognizes recreation as one of the public trust uses that state agencies must take into account when managing tidelands and navigable waters and their tributaries.

Current Participation in Water-Dependent Recreation in California

California's temperate climate provides a long season for outdoor recreation, and water is a magnet for outdoor recreation. Figure 1 shows the percentage of Californians participating in various water-related activities. In 2002, approximately 150 million adult participation-days were spent in recreation activities that are directly dependent on water. Many more visitor-days were spent in nature-based activities such as wildlife viewing (55 million adult participation-days) and hiking (36 million adult participation-days). In addition, water-dependent activities and experiences are a large draw to tourists, helping to attract 28 million visitors in 2001. It is not surprising that many of the popular outdoor recreation activities are dependent on or enhanced by water resources.

The 2002 *Public Opinion and Attitudes on Outdoor Recreation in California* clearly shows strong support for water related activities.

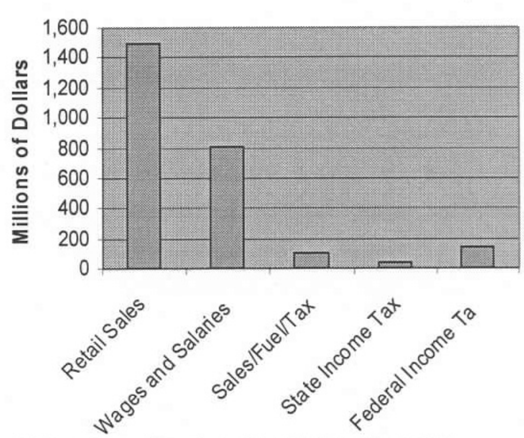
- Slightly more than 80 percent of the respondents indicated that more outdoor recreation areas, such as picnic and camping sites, are needed at lakes and reservoirs.
- When asked to assign a priority score from one (extremely low priority) to ten (extremely high priority) for providing more public use opportunities at lakes and reservoirs, nearly 85 percent recorded a 5 or better and 16.7 percent gave it a ten, an extremely high priority.
- Nearly 79 percent of the respondents indicated that the availability of water features (lakes, reservoirs, rivers, and wetlands) was either very important or somewhat important factor in their overall enjoyment of their favorite outdoor recreation activity.

Benefits from Water-Dependent Recreation

Water-dependent recreation provides a wide range of health, social and economic benefits to California residents and visitors, while improving the quality of life. It encourages physical activity, such as swimming and paddling as well as walking and bicycling along attractive waterside trails.

Water-dependent recreation influences tourism, business and residential choices. It increases expenditures in the community for travel, food and accommodations. In 2001, California had 28 million out-of-state tourists spending an average of $76 a day and staying an average of four days. In addition, 196 million resident tourists spent an average of $70 a day. Sales of sportfishing licenses and stamps generated more than $49 million in annual revenue for the Department of Fish and Game in 2001 and 2002.

Figure 2: 2001 Economic Impact of Freshwater Fishing in California (2,206,382 Licensed Anglers)



Data source: American Sportfishing Association

Water-dependent recreation prompts long-term investments while creating jobs in concessions, hotels, restaurants, and retail stores. Figure 2 shows economic information for freshwater fishing, only a portion of all water-dependent recreation; total economic output from freshwater fishing exceeded $3 billion.

Potential Costs

Initial development costs of recreation facilities can vary with the size of the project. Generally 3 percent to 6 percent of total project costs are allocated for development of permanent recreation facilities. For example, the capital cost of recreation facilities located on the State Water Project is about 3 percent of all capital expenditures for the SWP. Annual maintenance costs are just over 3 percent of the initial development costs of recreation facilities.

Major Issues Facing Water-Dependent Recreation

There are major issues facing the provision of increased and improved water-dependent recreation opportunities in California.

Funding

Funding concerns usually transcend all other issues affecting outdoor recreation facilities, including those for water-dependent recreation. These funding issues fall into two categories: planning and development of new recreational facilities associated with water management projects, and operation and maintenance of recreational facilities once they are in place. When new water facilities are being planned and built, there may not be adequate funding to fully incorporate recreational facilities. One reason for this is that the beneficiaries of recreation facilities may be different from the other beneficiaries of the water project, requiring complex funding mechanisms to fully support recreation planning. This is a significant issue in State Water Project Planning: the Davis-Dolwig Act specifies that water users shall not be charged for the cost of recreation facilities, but other funding mechanisms have not always been made available. Maintenance of recreational facilities may be more susceptible to funding cuts during poor economic conditions than for other resources thought to be more essential. Instability of funding can reduce the effectiveness of recreation providers to deliver quality, consistent and relevant facilities and services to meet growing demand. Many park and recreation providers have taken steps to reduce programs and operating costs to become more efficient on leaner budgets by raising fees and charges, reducing or eliminating services, delaying equipment purchases, and deferring land acquisition, facility developments, rehabilitation and renovation of aging infrastructure. Inconsistent funding also makes it difficult to plan for stable services and reduces the willingness of many service providers to offer new programs or to take risks.

Impacts to Natural Resources

Natural resource values often define the character and aesthetic appeal of a water-dependent recreation area, making it desirable and interesting to visitors. Overuse, misuse and poorly planned uses of any recreation resource can have a significant impact on natural resource values and on the experiences of those wishing to enjoy them. Water management can affect the amount or timing of stream flow. This may have a beneficial or harmful effect on recreation. Water managers should consider the effects of their actions on all resource values, including recreation as well as ecosystem health. Increasing numbers of visitors pursuing outdoor recreation activities threatens the proper functioning of ecosystems, disrupts and displaces wildlife and degrades the natural, environmental and aesthetic quality of an area and ultimately the very recreational experience being sought. In addition, visitors unfamiliar with ecological processes or environmental ethics are often unaware of the consequences of their actions.

Water Quality

Poor water quality can have a negative impact on water-dependent recreation in California. Contaminated lakes, rivers and streams not only may present health risks to those participating in water-contact recreation, but they can significantly diminish the recreation experience. One source of contamination is untreated sewage escaping from treatment facilities or broken sewer lines which have led to the highly publicized closure of public beaches. Human source contamination, untreated sewage discharged from houseboats and other pleasure craft is another source of pollution that has been a significant problem in the Sacramento-San Joaquin Delta. Fertilizers and chemicals from agricultural runoff also contribute to the problem.

Coordination

Funding and impacts to natural resources are exacerbated by the lack of coordination between those who manage water resources and those who provide recreational services. All too often, agencies are limited in scope and effectiveness in recognizing and mitigating trends affecting resource conditions, particularly outside their immediate jurisdiction. While partnerships and cooperation between agencies, organizations and individuals have grown, efforts at the watershed or landscape level are often fragmented, and opportunities are missed to achieve broader goals, placing both resources and the public at risk.

Recommendations to Help Provide Adequate Water-Dependent Recreation Opportunities

Recreation is an important strategy to be considered for water management. The following recommendations support improvements in water-dependent recreation:

1. In developing water-dependent recreation opportunities, jurisdictions should consider public needs as identified in the California Outdoor Recreation Plan.
2. Use existing data and new focused surveys to determine recreational needs that might be met by incorporating recreation more fully into new state and regional water project planning.
3. Develop closer working relationships among DWR, DFG, and DPR so that recreation planning is incorporated appropriately into CALFED program planning.
4. Conduct, and periodically re-examine, scientifically valid studies of the carrying capacity of proposed and existing sites for water-dependent recreation to help prevent degradation of water quality and wildlife habitat. Use data collected by other agencies, such as the U.S. Bureau of Reclamation, U.S. Army Corps of Engineers and for the Federal Energy Regulatory Commission (such as the results of FERC Relicensing studies).
5. Collect data on visitation rates vs. reservoir water levels and downstream flow rates, and use this data to help optimize the timing of water that is released or held for recreation.
6. Develop partnerships with universities to coordinate the monitoring of public recreation use, equipment and emerging outdoor and water-dependent recreation trends. Create partnerships with education providers to educate youth about preserving and protecting natural resources.
7. Promote and establish effective partnerships between federal agencies, state and local governments, and the private sector for operation, maintenance and law enforcement of water-dependent recreation facilities.
8. Coordinate with the Department of Fish and Game in exploring the use of funding from the Bay-Delta Sport Fishing Enhancement Stamp to integrate new and improved public angling opportunities.

Important Sources

- Multiple reports issued by the U.S. Army Corps of Engineers
- Department of Fish and Game, License and Revenue Branch, www.dfg.ca.gov
- Public Research Institute, “Survey of Boat Owners in California”
- Reports accessed at the Department of Parks and Recreation, Planning Division Library
- Department of Parks and Recreation, “Public Opinions and Attitudes on Outdoor Recreation in California 2002”, www.parks.ca.gov
- Department of Parks and Recreation, “California Outdoor Recreation Plan 2002”, www.parks.ca.gov
- American Sportfishing Association, www.asafishing.org
- California Department of Tourism, www.gocalif.ca.gov
- State Board of Forestry., California Department of Forestry and Fire Protection. “The California Fire Plan,” www.fire.ca.gov

Watershed Management

Watershed management is the process of evaluating, planning, restoring and organizing land and other resource use within a watershed to provide human benefits, while maintaining a sustainable ecosystem. Watershed management, as used in this plan, assumes that a prerequisite for any project is the sustained ability for the watershed to maintain the functions and processes that support the native ecology of the watershed. This does not imply that a goal is to return the watershed to an undisturbed condition. Instead it implies an integration of human needs and ecological condition that allows the watershed to sustain ecological integrity over time while providing for community needs. It is recognized that watersheds are dynamic and the precise make up of plants, animals, and other characteristics will change over time. Watershed management seeks to balance changes in community needs with these evolving ecological conditions**.**

What is a Watershed?

In its simplest context a watershed is an area of land with a single common drainage point. In the context emerging for planning purposes in California, a watershed includes living (including the people who live and work in the watershed) and non-living elements within a defined geographical area that is generally characterized by the flow of water. The flow of water defining a watershed includes both surface and groundwater as it moves through natural and manmade features, from higher elevations to lower elevations. Throughout the state we have engineered the flow of water such that defining watershed boundaries is often prefaced on hydrologic features but adjusted to accommodate water conveyance systems. In some cases planning watershed boundaries may be influenced by administrative boundaries as well, such as city limits.

Watersheds offer a convenient scale and context for considering how controllable factors can degrade or enhance the production of landscape goods and services. Watersheds collect all of California's precipitation, rain, snow and fog, filter or treat much of it, store more water than all of the state's reservoirs combined, and release water to rivers and groundwater at rates that vary with watershed conditions. Managing our watersheds can thus be thought of as the necessary maintenance of our natural infrastructure.

The natural processes that make watersheds vibrant and useful to us are vulnerable to upset and degradation and in turn our watersheds are vulnerable and susceptible to degradation and loss of the very features which sustain us. In recent years we have witnessed the effects of catastrophic fires, accelerated erosion, elimination or displacement of native vegetation, vast urbanization, and other processes that have diminished the overall quality of our watersheds. This can be seen in the decrease in water infiltration, increased maintenance costs from erosion related impacts, changes in the runoff of water, increases in the number of species that are threatened or endangered, loss of habitat and recreational opportunities, diminished scenic values, and the increasing difficulty that confronts that part of our economy which is directly dependant on the condition of our landscape for its well-being.

Chapter 4 of Volume 1 addresses some planning aspects of watershed management. The following narrative focuses on activities that can be undertaken to implement watershed management.

Issues Facing California Watersheds that Affect Water

Land uses alter hydrologic cycles – The hydrologic cycle includes precipitation as snow or rain, the flow of water over and through the land, and the evaporation of water back into the atmosphere. We can see that how we use the land has caused a reduction in rainwater infiltration and changed the timing and in some case the volumes of stormwater runoff. Storms, especially in urban areas but also in many agricultural areas are now marked by high intensity runoff over short periods of time. This creates greater flood risk and reduces the ability to capture water for our needs during dry times. From an ecological perspective, this compression of runoff events robs the streams and landscape of groundwater. This leads to drying of the land, a shift in vegetation types, lower and warmer streams, deterioration of stream channels, all of which leads to shifts in the plants and animals that can be supported. In some cases the diversion of water from streams or the application of water imported from outside the watershed has changed ecological relations or altered the flow of water through the watershed.

Human activities alter nutrient cycles - Another important natural cycle is the nutrient cycle. As we develop our watersheds we tend to increase the amount of water soluble nutrients, often concentrating them in fertilizers or biosolids. These concentrated forms of nutrients can trigger dramatic changes in water bodies, vegetation, and animal communities. Many native plants evolved under fairly low nutrient conditions. Increasing the available nutrients often allows invasive plants to overrun the native vegetation. This can reduce the infiltration capacity of the land and diminish the habitat quality. We also see that we often export nutrients from the location that they are generated. In some cases this is through the pollution of water which carries the nutrients to a point where they can support algae or other plant growth that impairs the water. In other cases this is through the transport of waste materials or the application of fertilizers. In any event, the result is an increase in nutrient loads that often diminish the ecological quality in water bodies.

Disrupting habitats and migration corridors - Life cycles and migration patterns of animals is another set of important cycles to consider. Many projects built in the past have unthinkingly disrupted migration corridors or destroyed or impoverished habitat that is critical for certain life stages of animals. Coastal wetlands that support breeding, nursery and rearing habitat for many ocean species have been particularly hard hit. Dams have blocked access to spawning and rearing habitats for anadromous fish. Riparian forests that support migration of South American birds, and inland wetlands that support the Pacific Flyway species have all been severally impacted.

Fire and water – The management of our forest and brush lands over the past few generations has created a risk of very large, very hot fires that do much more damage to watersheds than fires of historical intensities. The result is that watersheds are not capable of rapidly repairing the damage from these fires. These fires create long periods of erosion and diminish the plant communities that cover the land. They displace animals and limit the subsequent human use of the lands. This results in more water quality problems, more runoff and less infiltration, increased operations and maintenance costs for our reservoirs and canal systems, unstable lands, and large economic losses.

Underpinning Watershed Management is the need to understand ecological processes important to the local watershed of interest. Watersheds throughout California contain unique features. One approach to understanding these features it to describe various ecological cycles and important watershed traits, such as the hydrologic cycle, nutrient cycling, energy flow and transfers, soil and geologic characteristics, the role of fire, and animal migration and habitat utilization. Understanding these watershed characteristics allows for the application of adaptive management efforts and the operation of projects and programs to best fit into these ecological settings. In some cases the description of these characteristics will highlight that important infrastructure, programs, or projects are not sensitive to watershed processes or have not been designed to capture the full ecological value of the projects. In these cases reoperation or redesign may greatly improve the watershed compatibility of the projects.

Activities that Improve Watershed Management

1. Conduct normal business in a manner consistent with watershed dynamics and characteristics.
2. Design projects with ecological processes in mind and with a goal of making the projects as representative of the local ecology as possible.
3. Establish adaptive management programs that regularly assess the performance and condition of projects to determine if they are satisfying ecological and community needs. Adjust the operations or design the projects as needed.
4. Place projects in the watershed in a way that allows them to reinforce each other and build on the impacts collectively to support the local ecological cycles.
5. Increase the ability for precipitation to infiltrate into the ground, reduce surface runoff to a point where it reflects a natural pattern of runoff.
6. Restore and preserve stream channel morphology to allow access of flood waters to the floodplain and to provide for stable banks and channel form.
7. Maintain and create habitat around stream and river corridors that is compatible with stream and river functions. Provide as much upslope compatibility with these corridors as possible.
8. Rely on native plant communities where feasible in landscaping, agriculture, forestry, and restoration work.
9. Incorporate nutrient cycles that rely on the local watershed to supply and receive nutrients for important processes in the watershed.
10. Preserve features that support migration corridors or critical life stage habitats.
11. Sponsor and participate in watershed stewardship groups.

Current Watershed Management in California

Groups pursuing watershed management are now operating in all regions of California. It is estimated that several hundred watershed stewardship groups are now active in the state. A recent request of watershed management grant proposals produced more than 330 applications from all parts of the state. Proposals included both local and regional projects. Local projects addressed support for local stewardship groups, watershed assessment, planning and project implementation. Regional proposals centered on creating and coordinating networks for local watershed groups. From strictly private land holdings to consortia of public and private interests, people are focusing on the watershed scale as a way to create understandable and meaningful resource management efforts that provide multiple benefits and are designed to achieve sustainable ecosystems.

Current efforts at watershed management blend community interests and managing consistent with local ecology. The emphasis on community interests has introduced new methods for managing public discourse within stewardship groups and for collectively identifying principles and projects that are important to the local community. Issues of environmental justice have emerged and been blended into the more traditional project management approaches. Watershed stewardship groups serve as forums for coalescing the needs and capabilities of public and private sector interests, and people who work at the local, regional, state, national, and even international levels.

In addition to the local and regional efforts, a number of statewide initiatives have recently been undertaken to improve our overall ability to practice watershed management. Recent bond acts stress the need for integrated plans and contain incentives to design projects consistent with these plans. The bond acts and subsequent legislation associated with Propositions 40 and 50 have established statewide programs for Integrated Watershed Management and Integrated Regional Water Management that support managing resources on a watershed scale and conducting the public outreach, education, and project management required in watershed management efforts. A memorandum of understanding has been signed by the Resources Agency and the California Environmental Protection Agency that describes how the agencies will work in concert to promote watershed management. Two key features of this MOU are the establishment of the California Watershed Council, a public advisory body dedicated to developing recommendations to the agencies on how to improve watershed management, and a dedicated effort to coordinate grant programs in support of watershed management.

Recent legislation established the California Bay Delta Authority and, in part, assigned it the responsibility to maintain a Watershed Program. The initial goals of this program are to build local capacity to engage in watershed management, to promote the development of watershed assessments and plans, and to support specific projects designed to improve local management of watershed resources. The goals for the CBDA Watershed Program are to provide assistance, both financial and technical, for watershed activities that help achieve the mission and objectives of the CALFED (now CBDA), and to promote collaboration and integration among existing and future local watershed programs. The CBDA Watershed Program, with assistance from various state agencies, manages a grant program to achieve these goals.

The combination of a rapidly increasing number of local watershed management efforts and improved grant funding has broadened the interest in watershed management so that local public agencies that once relied on narrow program funding for support are engaging in watershed management to address their needs.

Benefits of Watershed Management

Water Supply Reliability and Management Flexibility

Watershed scale assessments, restorations, and project development has illustrated the potential to improve the ability to capture, store, and use water. For example, in the Feather River Watershed, meadow restoration has improved the ability of the watershed to capture snowmelt and spring runoff which in turn has lowered flood potentials and increased summer base flows in streams. This provides improved ability to capture water in summer months for export in the State Water Project. It also potentially reduces operations and maintenance costs of projects in the watershed and alleviates flood damage. These improvements are wholly consistent with the natural hydrology of the basin and serve to restore many ecological functions associated the meadow and stream systems.

Preserving Ecological Functions and Processes

Watershed management helps preserve ecological functions and processes by helping us consider natural cycles (hydrologic, nutrient, and life cycles) when designing projects. For example elevated stream temperatures are often identified as a problem. Promoting groundwater accretion to streams and improving riparian cover often cools stream temperatures. Designing projects to allow more water to soak into the ground, less water to sheet off as runoff, protecting the soil surface from erosion by planting native plants, and stabilizing stream channels with vegetated buffers brings the stream more in line with the natural watershed cycles and sustains important ecological processes.

Reducing Flooding Potential

Watershed management helps reduce flooding along streams draining the watershed. Preserving a more natural vegetated channel configuration and overflow areas helps slow and lower peak flows.

Improving Water Quality

Watershed management helps improve water quality by maintaining natural vegetated stream buffers that filter pollutants and nutrients.

Connecting to Other Things in the Watershed

Watershed management helps identify important aspects of the watershed that are connected within the working ecology. It helps identify how specific influences of a new project within the watershed have influences beyond the immediate project area. These influences in turn create opportunities for further watershed enhancements. In addition, it allows for easier identification of risks to sustaining the essential characteristics of the watershed. Understanding these influences provides opportunities to conduct business in a manner that is supportive of watershed dynamics.

Enduring Value

Watershed management provides the ability to generate enduring value from the integration of ecology and community interests. The melding of interests reduces or eliminates competition for resources, provides satisfying outcomes to a large number of people, and yields cost effective solutions. By describing interests behind programs, regulations, and personal positions, people are able to combine and integrate their work. Through this interest based approach, a stewardship ethic often emerges that serves to guide management. Communicating what is important to people creates opportunities for those who engage in the process to find strong allies throughout their community. Participation on a watershed management or stewardship group can give people a safe and open forum to express their ideas. Social tension around projects is replaced with broad ongoing support. Looking at the ecological dynamics from a watershed scale allows for practical descriptions of important processes and functions. Projects that are designed with this ecological scale in mind have a lower risk of being undermined by natural events than projects designed only looking at the site scale. Projects incorporating ecological conditions also preserve and enhance ecological conditions for future generations thereby contributing to fulfilling Public Trust responsibilities (see Volume 1, Chapter 2). Combining these features creates strong desires to maintain projects and continue to reap their benefits.

Costs Associated with Watershed Management

Costs associated with watershed management depend on site specific conditions such as the size of the watershed and actions to be implemented. In some cases, the actions will include physical projects to alter watershed conditions and in other cases the actions will be limited to programs that simply influence watershed use.

Currently, costs are incurred for measuring various features in the environment, planning projects, and building the projects. Incorporating ecological functions into projects represents a different perspective, but not necessarily added costs. For example, some nurseries in southern California have found that by growing plants in the peripheral drainage ditches of their properties they are able to reduce nutrient discharges and wastewater while growing a saleable crop. In agricultural settings tailwater ponds and vegetated canal systems have replace disking and spraying of field edges and canals banks. Providing stream systems access to their flood planes has reduced the potential damage from levee failures and lowered maintenance costs.

Some activities that may result in new costs (rather than simply redirecting existing expenditures) include watershed monitoring and assessment, support for watershed coordinators, increased restoration work, preservation of certain land use capabilities through easements or other forms of fee titled adjustments, and extended periods of time in planning and design to accommodate watershed ecology. Actual costs for these activities are difficult to estimate and may largely be offset by savings in other aspects of watershed management, such as water supply reliability, flood damage reduction, reductions in threatened and endangered species listings, and others.

Major Issues Facing Additional Implementation of Watershed Management

The major issues facing watershed management are:

Lack of Appreciation for the Role of Watersheds

In general the role of watersheds in sustaining our economies, businesses and communities is not fully appreciated. Providing for a greater understanding of watershed dynamics and how our communities and economies rely on their local watersheds will require working within formal educational settings, encouraging and engaging various sectors of the business community to become involved in watershed management, and providing opportunities and incentives to the larger community to be involved in watershed management.

Fairness, Inclusion and Decision Making

Because many watershed projects are collaborative in nature, projects often require coalitions of parties to successfully implement them. However, the governance structures for these groups are not standardized. They range from ad-hoc groups, to formal delegations of authority. The interest based discussions often take significant amounts of time. All interested people do not have the same ability to stay involved and therefore issues of fairness and inclusiveness in the decisions about projects can arise.

Science and Understanding

There is not a readily available source for finding key ecological information that can be incorporated into projects. Scientific assessments seek to provide a good technical description of watershed conditions, but cannot be definitive. State agencies can help in describing important ecological processes and functions throughout the state. As watershed assessment matures, a better understanding will likely emerge and more localized information will become available. Integrating ecological processes into project design, construction, and operations and maintenance will continue to be an evolving process.

Building Community Capacity

The ability for many local parties to engage in watershed management efforts is limited. In some cases the primary limitation is financial,with inadequate resources available to conduct assessments, support the coordination of stewardship groups, provide for private sector participation in ongoing planning and management groups, or implement projects. In other cases the limitation is a lack of exposure to watershed management concepts, and therefore, a lack of recognition of potential benefits and values that could arise from engaging in watershed management. The ability for groups to collaborate is often limited by existing program structures and management tendencies. Lack of collaboration can stifle watershed management efforts. Building networks of trust and sharing of resources and information will be needed to support collaboration at the watershed level.

Adaptive Management

Adaptive management requires the regular and periodic measurement of various watershed projects and characteristics. It also requires a method for assessing these measurements and designing and implementing responses to findings that suggest the watershed is not being managed in a sustainable manner or to produce the greatest value. In relatively few cases have we established and maintained the needed monitoring and assessment activities. Our efforts to respond to periodic assessments are often are not pursued from a watershed scale, instead being limited to project specific issues.

Recommendations to Help Promote Additional Watershed Management

1. State, federal, local, public and private interests should develop new means to collectively reinvest in sustaining watershed ecological and social health. Particular attention should be paid to developing means for urban areas to reinvest in sustaining the quality of rural watersheds that provide water supplies for the urban areas.
2. Watershed management assessments and plans must include quantitative efforts to improve water supply flexibility and the timing and amount of water available for diversion without compromising watershed ecological health.
3. State grant fund distribution should be based on meeting specific criteria that support watershed assessments, planning, public process management, and integrated project design and operations that result in multiple benefits.
4. Education efforts to inform the general public and specific constituencies about the role watersheds play in sustaining their communities should be undertaken at all levels of watershed management. Specific efforts to link to formal education including K-12, community colleges, and universities should be undertaken by state grant programs and agency programs working on watershed scales.
5. State agencies should pursue the goals and initiatives in the California Agency Watershed Management Strategic Plan (draft August 18, 2003).
6. State and local agencies should improve and expand their expertise in broad-based public decision making processes and participate in watershed stewardship groups. Attention should be paid to improving the use of stewardship group processes to help in achieving agency program responsibilities.
7. Watershed management efforts should design and implement, supported with state, federal, and local resources, adaptive management programs that include monitoring, assessment, and processes for defining project redesign and re-operations that bring management efforts more in line with local ecological functions.

Water Transfers

Water transfers are defined in the Water Code as a temporary or long term change in the point of diversion, place of use, or purpose of use due to a transfer or exchange of water or water rights[1]. Many transfers, such as those among contractors of the SWP or CVP, do not fit this formal definition. A more general definition is that water transfers are a voluntary change in the way water is usually distributed among water users in response to water scarcity. Transfers can be from one party with extra water in one year to another who is water short that year. Transfers can be between water districts that are neighboring or across the state, provided there is a means to convey and store the water. Water transfers can be a temporary or permanent sale of a water right by the water right holder; a lease of the right to use water from the water right holder; or a sale or lease of a contractual right to water supply. Water transfers can also take the form of long-term contracts for the purpose of improving long-term supply reliability. Generally, water is made available for transfer by 5 major sources:

1. Transferring water from storage that would otherwise have been carried over to the following year. The expectation is that the reservoir will refill during subsequent wet seasons.
2. Pumping groundwater in lieu of using surface water delivery and transferring the surface water rights.
3. Transferring previously banked groundwater either by directly pumping and transferring groundwater or by pumping groundwater for local use and transferring surface water rights.
4. Making water available by reducing the existing consumptive use through crop idling/crop shifting or by water use efficiency measures.
5. Making water available by reducing return flows or seepage losses in conveyance systems that would otherwise be irrecoverable for reuse.

Water transfers are sometimes seen as merely moving water from one beneficial use to another. However, in practice many water transfers become a form of flexible system reoperation linked to many other water management strategies including surface water and groundwater storage, conjunctive management, conveyance efficiency, water use efficiency, water quality improvements, and planned crop shifting or crop idling. These linkages often result in increased beneficial use and reuse of water overall. One of the most valuable aspects of water transfers can be the flexibility to take advantage of different water management strategies and foster cooperation among water agencies. Transfers also provide a flexible approach to distributing available supplies for environmental purposes.

Current Water Transfers in California[2]

Statewide, water transfers have significantly increased since the mid-1980s. Temporary and long-term transfers between water districts increased from 80,000 acre-feet in 1985 to over 1,250,000 acre-feet in 2001 (see figure 1). About 80 percent of this volume is traded on a short-term basis, within the same year. The remaining 20 percent is considered long-term, for durations ranging from two to 35 years. Since 1998, there have been several permanent transfers of water rights and contracts with the Central Valley Project and the State Water Project for up to 175,000 acre-feet per year.

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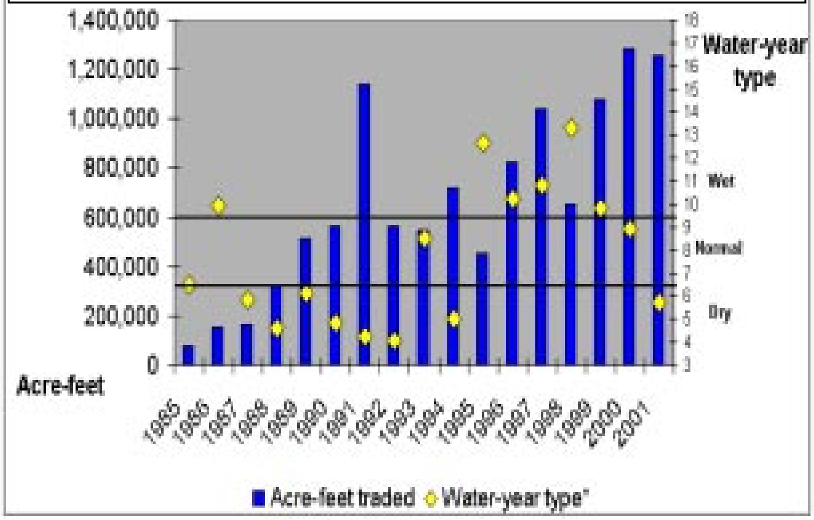
[1] Temporary water transfers, Section 1728 of the California Water Code, have a duration of one year or less. Long term water transfers, Section 1735 of the California Water Code, have a duration in excess of one year.

[2] Data in this section are drawn from Chapter 2 and Appendix A of *Who Should Be Allowed to Sell Water in California? Third-Party Issues and the Water Market*, Public Policy Institute of California, 2003. Ellen Hanak. (available for download at www.ppic.org). These data do not include transfers between farmers within the same water district, which can be substantial in some places.

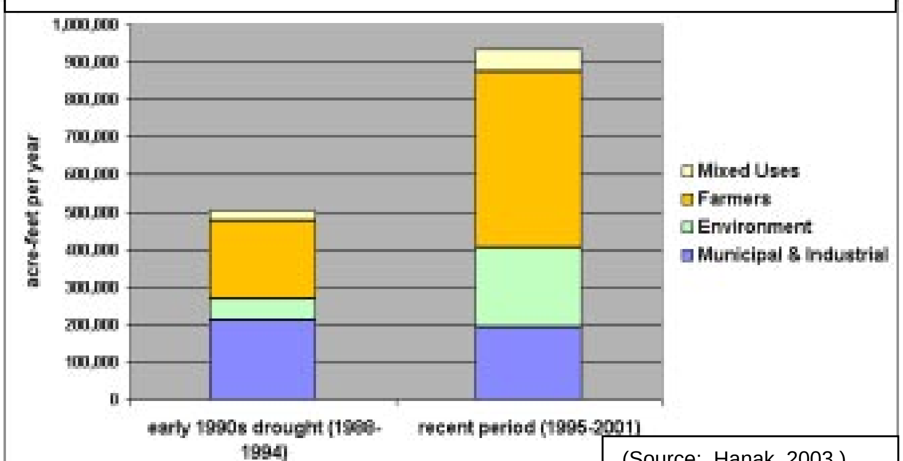
Figure 1. Temporary and Long-Term Water Transfers in California



Source: Hanak, 2003. * Note: Water-year type is measured by the Sacramento River 40-30-30 index, an indicator of water supply conditions for the state's primary river system.

Statewide water conditions have encouraged water transfers as a management strategy. Transfer activity increased substantially during the drought of the late 1980s and early 1990s, especially through the state-run Drought Water Bank and other drought-related state and federal programs. Transfers continued to increase since the mid 1990s, generally a much wetter period. Throughout this period, water transfers have primarily been from agricultural water districts, although in some wet years urban districts in Southern California have also transferred water to other users. The pattern of transfers has changed somewhat between the prolonged drought in the early 1990s and the more recent period (Figure 2). Although urban water districts were a primary destination in the early 1990s, accounting for over 40 percent of all transfers, their transfers have remained flat since the mid 1990s and now account for only 20 percent of all purchases.

Figure 2. Water Transfers by Type of End-User



(Source: Hanak, 2003.)

Two sectors responsible for most growth in transfers have been environmental programs and agriculture. Environmental purchases to benefit wildlife refuges and instream fish populations began during the early 1990s drought. They have increased considerably under the Central Valley Project Improvement Act and CALFED's Environmental Water Account, accounting for roughly 25 percent of the total since 1995 and as much as one-third by 2001. Agricultural districts now account for half of all transfers, and have been responsible for two-thirds of growth in transfers since 1995. The bulk of this increase is destined for farmers in the San Joaquin Valley and Tulare Basin, who have turned to transfers for replacement water in response to cutbacks of contract allocations under the Central Valley Project Improvement Act. Typically, farmers purchase water on a year-to-year basis. Most long-term and permanent transfers are destined for urban users.

Three regions are major participants in water transfers: the 10-county Sacramento Valley, the 8-county San Joaquin Valley and Tulare Lake Basin, and the 7-county Southern California region.[3] In most years, roughly 75 percent of transfers originate within the Sacramento and San Joaquin Valleys, with the remainder from Southern California. Overall, most transfers are between users within the same county (nearly 25 percent) or within the same region (nearly 50 percent). Interregional transfers account for the remaining 25-30 percent of transfers. Only 20 percent of these transfers are negotiated directly between parties in different regions; the rest move through programs run by DWR and USBR.

Current Oversight of Water Transfers in California

Before the Drought Water Bank program, water transfers were usually arrangements between two parties, one with extra water and one with unmet water demands. These parties would reach a mutually acceptable arrangement regarding price and quantity. Because public rights in water have always been recognized, approval by appropriate state and federal agencies has been viewed as a necessary part of the process for these independent water transfers. Transfers which involve changes in place or purpose of use of permitted or licensed water rights most often require the approval of the State Water Resources Control Board. Transfers which require the use of state or federal facilities or which may affect project operations require the concurrence or approval of DWR and/or USBR. State water law generally requires that transfers not injure any other legal user of water, not unreasonably affect fish and wildlife, and not unreasonably affect the overall economy of the county from which the water is transferred[4]. State agencies must consider the effects on public trust resources when participating in or approving water transfers.

The Drought Water Bank, Dry Year Purchase Programs, Environmental Water Account (EWA), and Central Valley Project Improvement Act have increased the role and responsibilities of state and federal agencies in the water transfer process. A large portion of water transfers each year now occur either under the guidance of, or funded by, a state or federal program. The complexity of cross-Delta transfers and the need to optimize the use of both CVP and SWP facilities, make USBR and DWR critical players in the water transfer process. The rules that govern water transfers within the SWP or CVP typically protect water users within these projects from the potential adverse effects of water transfers made by other project users.

The EWA is an element of the CALFED Bay-Delta Program's overall Management Strategy for the Bay-Delta Ecosystem that is administered, managed, and implemented by five federal and state agencies (U.S.

[3] Data availability allows regional definitions for county groupings, but not DWR's hydrologic regions. Notably, Southern California includes both the South Coast and Colorado River hydrologic regions (Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura counties), and the San Joaquin Valley includes both the San Joaquin River and Tulare Lake hydrologic regions (Fresno, Kings, Kern, Madera, Merced, San Joaquin, Stanislaus, and Tulare counties). Sacramento Valley counties include Butte, Colusa, Glenn, Placer, Sacramento, Shasta, Sutter, Tehama, Yolo, and Yuba.

[4] California Water Code Section 1810 *et seq*. specifies the requirements that must be met in order for DWR and other regional and local agencies to allow use of their conveyance facilities. Also, Water Code Sections 386, 1702, 1706, 1727 and 1736 follow the common law and establish similar requirements for changes in water rights. Strictly speaking, economic issues are typically only required to be evaluated in water transfers that seek to utilize DWR's water conveyance facilities or those of other State or local agencies. However, economic impacts that are associated with physical changes to the environment may require analysis under the California Environmental Quality Act (CEQA).

Bureau of Reclamation, California Department of Water Resources, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and California Department of Fish and Game). EWA's purpose is to provide protection to the fish of the Bay/Delta Estuary through environmentally beneficial changes in the operations of the CVP and SWP at no uncompensated water cost to the projects' users. EWA reduces Delta exports or provides other modifications to CVP and SWP operations at critical times for added protection to at risk fish species above that provided by the existing regulatory baseline. These changes in operations can cause reductions in water supply to users south of the Delta. Therefore, EWA obtains water to replace the water not delivered to CVP and SWP contractors in the Delta export service areas due to these changes in CVP or SWP operations by EWA.

Enactment of the Central Valley Project Improvement Act (CVPIA) in October 1992 provided new authority and expanded flexibility to Reclamation to allow transfers of federally developed water. One purpose of the CVPIA is to improve CVP operational flexibility and increase water-related benefits provided by the CVP through expanded use of voluntary water transfers. The water transfer provisions of the CVPIA govern the transfer of CVP water. These provisions authorize CVP users to transfer, subject to certain conditions, all or a portion of contract water to any California water user or agency, state or federal agency, Indian Tribe or private nonprofit organization for any purpose recognized as beneficial under state law.

Controversy regarding the effects on water users, fish and wildlife, and local economies strained the Drought Water Banks of the early 1990s. In response, DWR and USBR developed guidelines for implementing water transfers conducted within their areas of responsibility. The purpose of the guidelines is to help resolve issues and clarify the technical aspects of water transfers that need consideration when contracting with these agencies to either sell or convey water made available through water transfers.

DWR and USBR Water Transfer Guidelines

- DWR has published water transfer guidelines in a series of white papers available on DWR's Water Transfers Office Web site /www.watertransfers.water.ca.gov
- Reclamation, upon enactment of CVPIA, issued "Interim Guidelines for the Implementation of the Water Transfer Provisions of Central Valley Project Improvement Act", available from Reclamation's Water Transfer Program office.

In addition, DWR and water districts in northern California have begun to develop better mechanisms to respond to concerns over potential transfer effects on local water users and the environment. Cooperative monitoring and rapid response programs have been implemented to identify and protect or mitigate potential impacts on groundwater levels from groundwater substitution programs. Data from monitoring programs and open communication with parties that could be affected have helped identify groundwater issues as they developed and before adverse impacts became serious. Districts took actions to halt pumping, deepen wells, and work with parties that could be affected to prevent or mitigate impacts caused by water transfers.

Local leadership and initiative are also needed to implement water transfers. Water transfers are typically proposed by local water agencies and can benefit from local community involvement in the development of these proposals. Some counties have passed local ordinances to regulate groundwater extraction for water transfer purposes. With adequate public notice, disclosure of proposals and meaningful public participation, local communities can best assess their area's water demands and supplies and determine if there is potential for transferring water outside of the local region.

An example of local leadership in implementing water transfers is the December 1988 Water Conservation Agreement (Agreement) between Imperial Irrigation District (IID) and Metropolitan Water District of Southern California (MWD) and in the December 1989 Approval Agreement among IID, MWD, Palo Verde Irrigation District (PVID) and Coachella Valley Water District (CVWD). The Agreement provided for water conservation from 17 projects to be constructed by IID under the Program. Projected water conservation, when the final project was placed into operation, was 106,110 acre-feet (AF) of water per year. MWD funded all costs of the new projects in return for having this additional amount of Colorado River water available for diversion through its Colorado River Aqueduct.

The Agreement called for a Program Coordinating Committee (PCC) to secure effective cooperation and interchange of information and to provide consultation, review, and approval on a prompt and orderly basis between IID and MWD in connection with various financial, economic, administrative, and technical aspects of the Program. The Approval Agreement called for a Water Conservation Measurement Committee (WCMC) to provide an orderly basis, among the parties, for verification of the amount of water conserved and different amounts conserved by the individual projects. All Program actions of the PCC are to be approved by a majority vote. WCMC decisions, however, are to be approved by unanimous vote. If unanimity is lacking, the matter is taken up according to a dispute resolution procedure set forth in the Approval Agreement.

Potential Benefits from Water Transfers

For receiving areas, water transfers have the potential of reducing economic disruption, maintaining community stability, and improving environmental conditions that can deteriorate with water scarcity. Sellers can use the compensation from transfers to fund beneficial activities, although there is no guarantee that benefits to the seller will benefit the source area as a whole. Compensation from most transfers involving agricultural water goes directly to the participating landowner. In some cases, compensation goes to water districts, which can use the income to reduce water rates, improve facilities, or improve environmental conditions. For example, Western Canal Water District used proceeds from drought water bank sales to remove diversion dams and reconfigure its canals to reduce impacts on threatened spring-run salmon. Farmers can reinvest back into the farming business. Transfers by regional water agencies can provide additional resources to benefit the entire community. For example, the Yuba County Water Agency has used over $10 million from the proceeds of water transfers over the past several years to fund needed flood control projects.

In addition to the approximately 1.2 MAF transferred annually in recent years, there are several long-term transfers pending or approved since 2003 shown in Table 1. These include transfers under the Colorado River Quantification Settlement Agreement. Beyond those transfers shown in Table 1, economic studies[5] indicate that about 300 TAF in the Sacramento Valley and 400 TAF in the San Joaquin Valley could be made available through crop idling without unreasonably affecting the overall economy of the county from where the water would be transferred. These studies estimate that the economic effects of idling up to 20 percent of the rice land in the Sacramento Valley and up to 20 percent of the cotton lands in the San Joaquin Valley in any given year are near 1 percent or less of the county-wide economy, except in Glenn

[5] Studies conducted for preparing the Public Draft EIR/EIS for the Environmental Water Account dated July, 2003.

and Colusa counties where the impact would be less than 5 percent of the county-wide economy. The amount of land that would be idled is less than 10 percent of the total agriculture lands in these counties. The studies did not evaluate the economic effects of crop idling on commodity markets.

Table 1. Pending or Approved Long-Term Water Transfers[6]

Seller	Buyer	Maximum Annual Acre-feet	Duration (years)	Purpose (from/to)
Imperial ID	San Diego County WA	200,000	45-75	Agriculture to Agriculture and Urban
Imperial ID	Coachella Valley WD	103,000	45-75	Agriculture to Agriculture
Imperial ID	Metropolitan WDSC	110,000	54-90	Agriculture to Urban
Butte WD	Madera ID and Root Creek WD	15,000	25	Agriculture to Urban
Merced ID	U.S. Fish and Wildlife	47,000	10	Agriculture to Environment
Palo Verde ID	Metropolitan WDSC	111,000	35	Agriculture to Urban
South San Joaquin ID	Cities of Tracy, Escalon, Manteca, and Lathrop	75,000	25	Agriculture to Urban
	Total	629,000		

A statewide economic-engineering optimization study by the University of California, Davis (Jenkins, et al. 2001; Newlin et al. 2002) highlights potential benefits of water transfers to meet forecasted future water scarcity. Results suggest that by 2020 water transfers combined with conjunctive management and various operational changes could provide additional economic benefits as high as $1.3 billion per year statewide by reducing forecasted economic impacts of water scarcity as much as 80 percent. Almost all of the benefit comes from intra-regional water transfers and operational improvements within five regions of California, especially in southern California. The study indicates that the maximum reduction in deliveries to a major water user would be 15 percent with most transfers averaging much less. The study concludes that only a small proportion of California's water need be transferred to achieve significant economic benefits. Much of the added benefits would be from increased flexibility added to the water management system through reoperation of surface water and groundwater supplies using conjunctive management. These results represent a simplification of California's water management system and do not address legal and institutional barriers that may prevent full implementation.

Potential Costs of Water Transfers

The direct costs of completing a water transfer includes more than just the sale price of water, which is typically at the last point the seller controls the water. Additional direct costs to the buyer include conveyance, storage, and treatment costs, and seepage losses between the location and time of sale and the place and time that the water is used by the buyer. Sale prices reflect the cost to make the water physically available and, in some cases, added monitoring or mitigation needed to ensure compliance with federal and State Legislative guidance related to water transfers. The buyer typically arranges for transferred water to be conveyed to their area of use. Conveyance costs can be significant, as much as the price paid to the seller. For example, prices paid to the seller in 2002 and 2003 for the Environmental Water Account and Dry Year Water Purchase Programs operated by DWR ranged from $75 to $185 per

[6] Data in this table are updated from Table A.5 of Ellen Hanak, *Who Should Be Allowed to Sell Water in California? Third-Party Issues and the Water Market*, Public Policy Institute of California, 2003 (available for download at www.ppic.org). These data do not include transfers between farmers within the same water district, which can be substantial in some places.

acre-foot. The lower prices reflect a source in Northern California and the higher prices reflect the price to EWA of banked groundwater and conveyance costs in Kern County in years of 50 percent State Water Project allocations.

In addition to the direct costs of a water transfer to the receiving areas, indirect costs to third parties also can occur, and there could be impacts to other water users and the environment from water transfers. These concerns are discussed under the issues that follow.

Major Issues Facing Water Transfers

The major issues facing water transfers are:

Maintaining agricultural productivity

Because most water transfers come from agriculture, it is important to include the protection of agricultural productivity and economic benefits in water transfer policies. A key challenge is to balance the ability of agriculture to provide water for transfers on a periodic basis to help with temporary water scarcity with limits so that transfers do not destabilize California's agricultural productivity and economy.

Balanced Approach to Regulating Transfers

There is a concern by some that existing state laws and oversight of water transfer are not adequate to protect the environment, third parties, public trust resources, and broader social interests that may be affected by water transfers. This is particularly the concern for water transfers involving pre-1914 water rights, which are not subject to regulation by SWRCB, and transfers that involve pumping groundwater or crop idling and crop shifting. Conversely, there is also concern that efforts to more heavily regulate water transfers may unnecessarily restrict many short-term, intra-regional transfers that have multiple benefits during temporary supply shortages and that have little likelihood of direct or indirect impacts. The key issue is how to balance these concerns to allow water transfers to continue as a viable water management strategy while having mechanisms to minimize effects on others.

Environmental Concerns

Environmental consequences of transfers could occur in three places: the area *from* which water is transferred, the area *through* which water is conveyed and the area *to* which water is transferred. Cumulative effects of short- and long- term transfers could have impacts on habitat, water quality, and wildlife caused by substituting groundwater for surface water, changing the location, timing, and quantity of surface diversions, or changing crop patterns through crop shifting or idling. For example, rice growing areas could have significant secondary benefits as wildlife habitat. Transfers that involve crop idling in these areas could either harm or benefit wildlife depending on implementation. Transfers that involve increased groundwater pumping also raise concerns over groundwater overdraft and the long term sustainability of groundwater resources. In addition, long term water transfers that induce new urban development in the receiving area may have environmental impacts.

Using Limited Duration Transfers for Long-Term Demands

There is a concern that transfers of limited duration are being used for long-term demands. For example, transfers under the Environmental Water Account, Central Valley Project Improvement Act, and related programs are designed to improve environmental conditions. Because these transfers rely on public funding that may not exist every year, they may not provide long term protection for the environment. There is also a concern that urban areas may use limited duration transfers to accommodate population growth with water supplies that are not sustainable. Finally, there is a concern that agricultural areas may use limited duration transfers to supply crops, such as orchards, that cannot be easily scaled back during droughts.

Economic Concerns

Short term, out-of-county transfers created through extensive crop idling can reduce production and employment of both on farm and secondary economic sectors resulting in reduced tax revenues and increased costs for farmers not participating in the transfer. Extensive idling of crops that resulted in unemployment of manual laborers could be considered unfair treatment under the state's environmental justice policies (see Government Code Section 65040.12). In addition reduced revenues could affect local governments disproportionately with potential impacts to spending on a wide range of services provided by local government. Long-term transfers could result in similar impacts even though the amount of fallowed land may be less. For long-term transfers, impacts to other elements of the local community (schools, businesses etc.) may be more widespread and severe. Transfers of surface water that are replaced by increasing groundwater pumping may drop groundwater levels and increase the pumping costs to other groundwater users.

State law generally requires that water transfers not unreasonably affect the overall economy of the county from which the water is transferred (referred to as source areas). However, there is potential for some economic disruption to source areas depending on the source of transferred water, the amount of water transferred, and the duration of the transfer. A review of past water transfers has not shown long-term economic impacts to source areas. There is a concern that these areas could experience long-term economic impacts if transfers become more widespread. Water scarcity can also cause economic impacts, both where the shortage occurs and far beyond. Water transfers can help reduce water scarcity in areas receiving transfers thereby helping to avoid job losses and secondary economic impacts in these areas.

Quantifying Uncertainties and Effects on Others

Transfers, especially those where water is moved long distances, are limited by several factors including access to and physical capacity of conveyance systems, environmental and water quality regulations, losses along the flow path, linkages between surface water and groundwater movement and use, and other factors that are difficult to quantify or anticipate. Those who traditionally relied on return flows from upstream areas as a source of supply are concerned about changes in timing and quantity of flows resulting from water transfers or water conservation measures. Quantifying the actual water savings from crop shifting and crop idling is particularly difficult because only the consumptive use by the crop is transferable in most cases. There is a risk that estimates of the water supply benefits from the transfer to the water system (estimates of "real water") will be inaccurate and that the transfers have unintended consequences to other water users, local economies, or the environment. A key challenge is to improve methods for quantifying these uncertainties and to include adequate monitoring and assurances when implementing water transfers. Monitoring is particularly critical for transfers that either result in water savings from crop idling, crop shifting, or increase groundwater use. Information may be needed on historical and current land use and water use, groundwater levels, land subsidence, water quality, environmental conditions, and surface water flows.

Need For More Integrated Management of Water Resources

In California, authority is separated among local, state and federal agencies for managing different aspects of groundwater and surface water resources. Several examples highlight this: 1) SWRCB has jurisdiction for appropriative water rights dating from 1914, but disputes over appropriative water rights dating before 1914 are settled by the court system; 2) Similarly, SWRCB has jurisdiction over groundwater quality, but disputes over groundwater use are settled by the court system ; 3) County groundwater ordinances and local agency groundwater management plans often only apply to a portion of the groundwater basin, and those with overlapping boundaries of responsibility do not necessarily have consistent management objectives. Failure to integrate water management across jurisdictions makes it difficult to develop transfers with multiple benefits, provide for sustainable use of resources, identify and protect or mitigate potential impacts to third parties, and ensure protection of legal rights of water users, the environment, and public trust resources.

Infrastructure and Operational Limits

The ability to optimize the benefits of water transfers depends on access to and the physical capacity of existing conveyance and storage facilities. For example, when export facilities in the Delta are already pumping at full capacity, transferable water cannot be moved. This occurred in 2003 when the Metropolitan Water District of Southern California (MWDSC) negotiated water transfers with growers in the Sacramento Valley but was unable to move water through the Delta where the conveyance system was flowing full, or to store the water in Lake Oroville, which filled with late spring rain. The ability to convey water is also an important aspect of the potential water transfer between the Imperial Irrigation District and the San Diego County Water Authority, which requires access to the Colorado River Aqueduct owned and operated by MWDSC.

Recommendations for Water Transfers

1. Since local government and water agencies have the lead role in developing and implementing water transfers they should:
    a. Develop groundwater management plans to guide implementation of water transfers that increase groundwater use or that could impact groundwater quality.
    b. Implement monitoring programs that evaluate potential specific and cumulative impacts from transfers, provide assurances that unavoidable impacts are mitigated reasonably, and demonstrate that transfers comply with existing law.
    c. Evaluate and implement regional water management strategies to improve regional water supplies to meet municipal, agricultural, and environmental water demands and minimize the need of importing water from other hydrologic regions.
    d. Provide for community participation when addressing conflicts caused by transfers within their jurisdictions.
2. State and federal agencies, in addition to implementing state and federal law, should assist with resolving potential conflicts over water transfers when local government and water agencies are unable to do so and when there are overriding state or federal concerns.
3. State and federal agencies, working through the CALFED Water Transfers Program, continue to gain consensus on how best to implement water transfers. The following actions are on-going and should be continued and improved:
    a. Preparing programmatic and site specific CEQA/NEPA documents to assess cumulative effects of inter-regional transfers anticipated to occur under the Environmental Water Account and Sacramento Valley Water Management Agreement.
    b. The SWRCB, DWR, and DFG must consider whether the transfer is likely to harm public trust resources, such as fish and wildlife, and must protect trust resources whenever feasible. The SWRCB and DWR, after considering all available information, including CEQA

documents or other environmental documents and the input of DFG, may put conditions on transfer to protect trust resources. If the SWRCB or DWR find that proposed transfer will cause undue harm to trust resources, they may (1) add terms to avoid the harm (2) the SWRCB may deny the petition or (3) DWR may deny the use of its facilities. In many cases, transfers will not result in harm to trust resources.

   c. Under Section 1802 of the Fish and Game Code, DFG must exercise its responsibilities as trustee for the resources of the state with jurisdiction over the conservation, protection, and management of fish, wildlife, native plants, and habitat necessary for biologically sustainable populations of those species.
   d. Improving conditions in the Delta and identifying and reducing statewide conveyance limitations.
   e. Streamlining the approval process of state and federal agencies for water transfers while protecting water rights, the environment, and local economic interests.
   f. Working with agencies proposing water transfers that move water through the Delta to monitor and evaluate short-term, long-term, and cumulative effects that could impact the condition of the Bay-Delta ecosystem.
   g. Refining current methods on how to identify and quantify water savings for transfers using crop idling and shifting. This should be accomplished through a collaborative process that considers methods developed by others.
   h. Developing, with interested parties, acceptable ways to identify, lessen, and distribute economic impacts from transfers that use crop idling and shifting.
   i. Providing financial assistance for local and regional groundwater management activities that promote sustainable and coordinated use of surface water and groundwater.
   j. Seeking consensus among interested parties about the role of water transfers as a water management strategy while identifying and protecting or mitigating potential impacts to other water users, third parties, the environment, and public trust resources.
   k. Providing technical assistance and guidelines for assessing cumulative impacts of the anticipated effects of proposed transfers, including concurrent or consecutive one-year transfers within the same region, on other water users, local economies, and the environment.

4. State and federal agencies, working through the CALFED Water Transfers Program, should implement the following actions to improve management of water transfers:
   a. Improve coordination and cooperation among local, state, and federal agencies with different responsibilities for surface water and groundwater management to facilitate sustainable transfers with multiple benefits, allow efficient use of agency resources, and promote easy access to information by the public.
   b. Develop water transfer policies that balance the ability of agriculture to provide water for transfers on a periodic basis to help with temporary water scarcity with limits so that transfers do not destabilize agricultural productivity and economic benefits.
   c. Facilitate cooperation between agencies proposing water transfers and regulatory agencies to obtain multiple benefits from proposals. For example, transfers intended for urban or agricultural use may also be scheduled to enhance flows for aquatic species in areas between the seller and buyer.
   d. Implement water transfers, when serving as a purchaser, in cooperation with local partners, consistent with state water and environmental laws, and at a fair price.

Information Sources

- CALFED. Water Transfer Program Plan. July 2000
- CALFED. Programmatic Record of Decision. August 29, 2000.
- DWR. Water Transfer Papers for Water Transfers in 2002 Involving the Department of Water Resources (Draft 3-8-02) (www.watertransfers.water.ca.gov)
- DWR. Draft EIR/S for the Environmental Water Account. July 2003.
- Governor's Advisory Drought Planning Panel. Critical Water Shortage Contingency Plan. December 29, 2000.
- Hanak, Ellen, "Who Should Be Allowed to Sell Water In California? Third-Party Issues and the Water Market". Public Policy Institute of California. San Francisco, CA, June 2003.
- Jenkins, M.W., et al, "Improving California Water Management: Optimizing Value and Flexibility," University of California, Davis, CA, http://cee.engr.ucdavis.edu/faculty/lund/CALVIN/, 2001.
- Newlin, B.D., M.W. Jenkins, J.R. Lund, and R.E. Howitt, "Southern California Water Markets: Potential and Limitations," Journal of Water Resources Planning and Management, ASCE, Vol. 128, No. 1, pp. 21-32, January/February 2002.SWRCB. A Guide to Water Transfers (DRAFT). July 1999.
- SWRCB. "Water Transfer Issues in California: Final Report to the California State Water Resources Control Board by the Water Transfer Workgroup". June 2002.